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WOS:mw
2-18-55

SOME NEW MATERIALS BEING SOLD AS SOIL CONDITIONERS AND FERTILIZERS

WHAT IS "CALFIDE"?

A material known as "Calfide" is being sold as a soil conditioner in certain counties of Illinois. Because it is sold as a soil conditioner, and not as a fertilizer, the company is not required, under Illinois fertilizer law, to show any analysis.

We wrote two letters to the Calcium Company of Salida, Colorado, producer of this material, asking for information regarding its identity and value, but received no answer.

We then wrote to various agencies in Colorado and to the Kansas Experiment Station, where it was tried out in plot and greenhouse experiments last year. Following are excerpts from the replies we received:

Agronomy Department, Colorado A. & M. College, Fort Collins, Colorado

"I have no complete analyses of this product and we have not used it in any experiments; however, I am informed by the State Department of Agriculture of Colorado that it contains 22 percent calcium, 15.5 percent sulfur, and is evidently composed primarily of gypsum. We would consider the product of some value in treating high alkaline soils with a high sodium percentage, but it is of no other particular value."

Colorado Department of Agriculture, Denver, Colorado

"Calfide is recognized in the state of Colorado as a gypsum product containing approximately 20 percent calcium, 15 percent sulfur, and iron, copper, lead, zinc, magnesium, cobalt, phosphorus and potash.

"Our law allows this to be registered as a soil amendment not sold as a fertilizer, and the only use we can permit them to advertise in our state is for a corrective with alkaline soils."

Kansas Agricultural Experiment Station, Garden City Branch Station, Garden City, Kansas.

"So far as we can determine this material is gypsum. It was originally sold by the Arkansas Valley Gypsum Company of Salida, Colorado, as gypsum. We have made a number of tests with this material in the field and in the greenhouse and have had absolutely no response. It is our opinion that this material will do only a small part of the claim made for it. Where gypsum can be used to advantage, this material might be substituted."

A news release from Purdue University states:

"A material known as 'Calfide' is being sold in certain counties in Indiana as a soil conditioner at prices up to $74.50 a ton. The office of the state chemist at Purdue University reports that this material is not a fertilizer, but that it appears to be from a deposit which contains limestone and gypsum."

It has been reported that salesmen claim this material to be radioactive. The value of radioactive material in crop production has been thoroughly studied by this and other experiment stations and by the U. S. Department of Agriculture. In none of these experiments have radioactive materials shown any benefit.

Under certain conditions, gypsum might be of some benefit as a soil conditioner and as a supplier of calcium. The gypsum itself does not correct acidity; the

value would be in any limestone that might be mixed with the gypsum. In the amounts recommended, however, the amount of limestone would be so small as to have no practical value for correcting acidity. The ordinary Illinois limestone will do the job better and many times cheaper.

As two of the previously quoted letters point out, calcium sulfate is used effectively in the West in helping to get rid of the sodium in black alkali soil. But black alkali is altogether different from the common alkali soils of Illinois.

WHAT IS GRANITE DUST?

Granite dust is being sold under the trade name of "Hybro-Tite" as a source of potash and various trace minerals.

An important mineral in granite rock is felspar. A large part of the potassium in soils occurs in the form of felspar potassium. The potassium in this mineral is not available to plants until the mineral breaks down, and this breakdown occurs very slowly. Granite dust contains about 4 or 5 percent total potash that would become available so slowly and in such small amounts as to make it of no practical value as a potash fertilizer.

WHAT IS GREENSAND MARL?

Greensand marl, also known as glauconite, is being sold under the trade name of "Kaylorite" for use as a potash fertilizer. This material is found in large deposits in New Jersey and other eastern states. The advertisements claim that it contains 8 percent total potash but only about 1 1/2 percent available potash.

Probably the best way to answer inquiries about greensand marl is to compare the 1 1/2 percent available potash it contains with the 50 or 60 percent available in muriate of potash. The trace elements it is also claimed to contain would have no practical value for Illinois soils.

C. M. Linsley
1/12/53

SUITABILITY OF ILLINOIS SOIL AREAS FOR PONDS

Because water storage is the main function of farm ponds,1/ it is important that there be no appreciable loss by seepage. Gravel, sand, coarse silt, and fissured rock do not hold water satisfactorily. On the other hand, clay is generally impermeable or only very slowly permeable. For this reason areas that have clay subsoils or substrata usually provide good sites for farm ponds.

In Illinois the permeability of the soils and underlying materials varies tremendously from one area to another. These differences are important in determining whether an area is suitable for pond sites. On the basis of permeability of the subsoil and substrata, Illinois soils have been divided into five main groups (Figure 1 and Table 1) according to their suitability for farm ponds. The characteristics of these groups are described below:

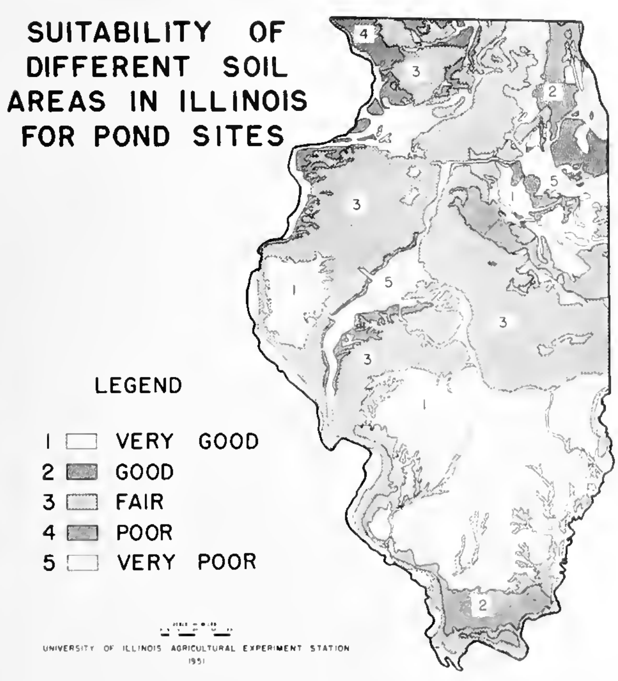


Figure 1

Group 1. There are many excellent pond sites in soil association areas M, N, O, P, and W2/ in southern and southwestern Illinois, where the soils developed from thin to moderately thick loess on weathered drift. Here the subsoils are fine textured and so slowly permeable to water that little or no seepage will occur if the pond is properly constructed.

The underlying Illinoian drift is also slowly permeable except on a few coarse-textured, isolated morainal ridges, notably those that extend from Pana southwest to Greenville. It is fortunate that surface water supplies may be obtained easily in Group 1 because groundwater is often deficient.

Good ponds may be easily constructed in the silty clay and clay till areas (area G) of northeastern Illinois because the soils and underlying calcareous till are nearly impermeable. However, the need for ponds is not great because good groundwater supplies are available from the drift and bedrock.

Group 2. It is rather easy to construct good ponds in northeastern Illinois where the predominant underlying material is a silty clay loam glacial till (areas E, F, and V). But here again the need is not great because groundwater supplies are generally adequate.

In the hilly, unglaciated section of extreme southern Illinois (area X), groundwater is deficient and ponds are needed to store surface runoff. The loess-derived soils are sufficiently impermeable to make it possible to construct good ponds. Where the loess is thin, however, it is advisable not to choose a site where there is fissured rock. In the part of area O farthest from the bluff, permeability is slow enough to prevent seepage.

Table 1.--Suitability of Predominant Illinois Soils for Pond Sites

Group No.	Suitability	Permeability: Subsoil	Permeability: Substrata	Groundwater supply
1	Very good (M, N, O, P, W)	Very slow to slow	Very slow to slow	Deficient
	Very good (G)	Very slow to slow	Very slow to slow	Adequate
2	Good (E, F, V)	Slow to mod. slow	Slow to mod. slow	Adequate
	Good (Q away from bluff, X)	Slow	Generally slow	Deficient
3	Fair (Q near bluff, Z)	Slow	Slow to moderate	Deficient (Q) Adequate (Z)
	Fair (K, L)	Mod. slow to mod.	Slow to moderate	Adequate
	Fair (C, D, H, I)	Moderate	Moderate	Adequate
4	Poor (J, T, U)	Moderate	Mod. to mod. rapid	Adequate
5	Very poor (R, Y)	Moderate	Moderate to rapid	Adequate
	Very poor (A, B, S)	Mod. rapid to rap.	Mod. rapid to rap.	Adequate

Group 3. In the parts of area Q nearest the bluff, ponds are frequently needed, but sites must be carefully chosen. In general the subsoils are slowly permeable, but the underlying deep loess is often permeable enough to permit excessive seepage.

In the gray terrace and bottomland soils of southern Illinois (area Z), the subsoils are fine textured and slowly permeable enough to be adapted to pond construction, but the underlying material is variable and requires careful investigation. Ponds are generally not needed because groundwater supplies are available.

Many good ponds have been constructed in areas K and L, but several factors need to be considered in selecting sites. The soils are developed from thick to moderately thick loess over weathered Illinoian glacial till or calcareous Wisconsin till. Where only moderately thick loess is underlain by weathered Illinoian till, as in west-central Illinois, there is less danger of seepage than where the loess is deeper near the bluff or where it is underlain by calcareous Wisconsin till, as in north-central Illinois.

Care must also be taken in selecting sites for ponds in areas C, D, H, and I, because the subsoils and underlying calcareous loam till are moderately permeable to water, and seepage will occur on all except the better sites. Fortunately, ponds are generally not needed in these areas because good groundwater supplies are available from drift or bedrock.

Group 4. In area J the deep permeable loess makes it difficult to find sites for ponds where excessive seepage will not occur. Satisfactory sites are also scarce in areas T and U, because the loess-derived soils are permeable and are generally underlain by bedrock that may be fissured.

Group 5. The medium-textured, dark-colored bottomland, terrace, and outwash soil areas (R and Y) contain very few satisfactory pond sites. The subsoils are moderately permeable and the underlying stratified materials are variable but sufficiently permeable to allow water to move freely both horizontally and vertically. Because groundwater is plentiful, ponds are rarely needed, however.

Soils developed from coarse-textured till or sandy material in areas A, B, and S make poor pond sites. The subsoils and underlying materials are generally so permeable that water moves readily downward to the watertable. However, adequate groundwater makes it unnecessary to rely on ponds for water in these areas.

Not all of the soils and soil conditions in Group 1 are particularly well adapted to pond sites, and not all of those in Group 5 are poorly adapted. The reason is that there are local soil variations that could not be shown in Figure 1. Even a detailed soil map does not provide enough information to make it possible to choose a pond site without further investigation.

The best way to select a location is to bore holes in a number of places to find out whether the soil is sufficiently impervious to water. Even in impervious areas there may be permeable wash in the bottom of natural watercourses. This permeable wash material should be removed or avoided if possible. It should not be used in the earth fill, except possibly on the dry side of the dam.

If it is necessary to construct a pond on moderately permeable soils, controlled silting3/ may help to make it watertight. Puddling the soil in the bottom may also be helpful.

In extreme cases a layer of clay may be placed over permeable soils to reduce seepage; or a swelling type of clay mineral, such as sodium bentonite (montmorillonite), may be used to seal pores in open soil material. Sodium bentonite absorbs nearly five times its weight in water and occupies about five times as much space when fully saturated as when dry. The bentonite may be used in any one of these three ways:

1. Spread evenly over the surface at the rate of about 1 pound of bentonite per square foot of soil, and then mix with the top three or four inches of soil by harrowing or hand raking.

2. Spread a layer of bentonite carefully over the surface, and cover with a layer of soil or sand two to four inches thick.

3. Sprinkle coarse particles (4 to 20 mesh) of bentonite on the surface of the water in an undrained pond. They will sink to the bottom, swell, and form a water-repellent gel.

In constructing a pond, first remove the topsoil from the entire area. Then use the least permeable material, such as the subsoil, in the core or center of the dam, the next best on the wet side, and the most permeable on the dry side. The topsoil may be pushed back on the dry sides of the dam after the fill is completed.

1/ Although ponds are sometimes used for gully control, this purpose is not included here.

2/ For soil association areas, see Ill. Agr. Exp. Sta. Pub. AG1443, entitled "Illinois Soil Type Descriptions."

3/ Excessive silting, such as may occur if ponds are located in deep, active gullies or downstream from cultivated land, is undesirable and should be avoided.

R. T. Odell
2/23/53

HAY AND GRAIN PRESERVATIVES

Chemical compounds are being offered for sale that, if applied at the rate of 5 to 10 pounds per ton of crop, supposedly prevent moist hay or grain from spoiling. Because large volumes can be treated rapidly, the use of such chemicals would appear to be an excellent emergency measure for preserving crops when bad weather prevents proper curing.

Farmers' interest has resulted in large sales and use of these compounds. Both success and failure have been reported from their use. Research at experiment stations, however, has not shown these materials to be effective.

Why these contradictory results? Much of the moisture in crops, especially hay, that are considered unsafe for storage is border line. Whether they are treated or not, some of them will undergo a prolonged "sweating" period that involves mild heating and some condensation of moisture near the surface. Although the heating causes considerable loss of dry matter, the farmer is not aware of the loss if the end product has good color and is free from visible mold. For this reason farmers who use compounds to preserve hay or grain that appears to be too moist for safe storage are convinced that the chemical is beneficial if the crop does not mold. Some of them will even write testimonials to that effect.

Manufacturers of hay and grain preservatives have a strong advantage in promoting their use because most of the time crops thought to be unsafe for storage are not severely damaged. But if the hay or grain is definitely too wet to store, the treated crop will become musty or moldy and there will be more heating, possibly to the point where charring and spontaneous combustion occur. Because of the possibility of combustion, it is dangerous to rely on ineffective compounds to preserve moist hay and grain. Then crop and building, as well as animals and stored machinery, may be lost.

Research indicates that preventing mold growth in moist hay or grain will eliminate most of the problem of heating and deterioration. Certain preservatives are claimed to be effective because they release carbon dioxide, which inhibits mold growth.

Molds will not grow in an atmosphere of pure carbon dioxide, but they will grow in high concentrations of carbon dioxide if some oxygen is present. It is impossible to exclude oxygen from the average hay stack or grain bin. Also, if carbon dioxide would prevent mold growth in stored crops, then moist hay or grain would preserve itself, because one ton of the moist crop releases 100 times as much carbon dioxide as 5 to 10 pounds of sodium bicarbonate (baking soda), which is the principal active ingredient of many so-called hay and grain "preservatives."

Drying compounds have also been suggested for treating moist hay and grain. The object is to reduce moisture content to a level where molds can't grow. To reduce one ton of hay with 35 percent moisture down to 25 percent, 265 pounds of water must be quickly removed or the hay will mold. This would require about 600 pounds of silica gel, one of the most effective drying substances.

It is not feasible to use the quantity of chemical necessary to dry moist hay.

Incidentally, mold will grow in hay if the moisture content is above 15 percent, but it usually does not cause excessive damage if the hay contains only 25 percent moisture or less when stored. Sweating reduces the moisture content to about 15 percent, but at the same time about a 5 percent loss of dry matter occurs.

Can moist hay and grain be preserved by treating with certain chemicals? Yes, but there are no compounds on the market that are known to be effective. Certain organic fungicides will definitely prevent mold growth on moist hay and grain, and they do not appear to be toxic to animals eating the treated crops. But at present these materials are not being sold because of cost or problems in handling.

A compound is not satisfactory as a hay or grain preservative unless it is a strong fungicide. If it is a strong fungicide, it must be carefully tested to be sure it is not toxic to humans handling it and to animals eating the treated crop.

Before a chemical is used, tests must be made to determine whether it appears as a residue in the animal product, milk, or meat. Not only must it leave no residue, but it must be inexpensive. It costs $5 a ton to treat moist hay with the cheapest fungicide that has shown promise as a hay and grain preservative. This compound has other limitations that prevent it from being recommended.

Although it is possible to preserve moist hay and grain with chemicals, at present it is not feasible. Furthermore, it is dangerous to rely on ineffective compounds to preserve these crops when spontaneous combustion may occur and cause large losses. Drying or in some cases ensiling is now the only reliable method for handling either moist hay or moist grain.

Keith Kennedy
3/30/53

AGRONOMY FACTS

USE OF ASPHALT IN ESTABLISHING GRASS SEEDINGS

Asphalt has been used in various forms for centuries as a road building material. It has been hard enough to withstand traffic and at the same time prevent vegetation from growing through the roadway. Now, with certain chemical and physical changes in the preparation of the asphaltic material, it will remain soft enough for plants to grow through it and at the same time be nontoxic to vegetation. It can therefore be used as a means of stabilizing the soil against erosion during the time grass stands are being established.

Asphalt occurs in native deposits as rock asphalt and as a residue of the petroleum industry known as asphalt cement. When reduced with oil, it is known as cutback. When reduced with water and an emulsifier, it is known as emulsion. Its hardness and elasticity can be controlled in the manufacturing process.

Asphaltic materials have been tested by the Agronomy Department of the University of Illinois during the past three years. The first tests were made in the greenhouse, where different types of asphalts were tried on varying soil materials, such as clay, silt, sand, and gravel. Different kinds of grasses were also tried. The ordinary road asphalts were not satisfactory because they were too hard for the grass to come through and they contained toxic oils.

Special cutback asphalt from the Lion Oil Company and special emulsion from Shell Oil Company were found to be satisfactory during these preliminary tests. After the greenhouse experiment, tests were made at the Agronomy South Farm, where seedings were made each week during the summer. These seedings were all satisfactory with the exception of those made during July and August.

The length of the normal seeding season can be extended somewhat by using asphalt. Tests show that temperatures are from 3° F. to 18° F. warmer in the asphalt treated plots than in the check plots. Evaporation is also cut down, providing a better moisture relation for the young plants.

Tests have also been made on terrace outlets in cooperation with the Soil Conservation Service and the Illinois Highway Department. Results of these field tests have been very good.

The first step in the use of asphalt as a mulch is to prepare the seedbed. It should be prepared in the usual way and worked down until it is firm and compact. On almost all lawns, waterways, highway shoulders, etc., complete fertilizer should be applied. A minimum of 60 pounds of nitrogen per acre should be used. This means that with a 10-10-10 fertilizer at least 600 pounds per acre should be applied. Sterile areas of subsoil may need as much as 1,000 pounds of 10-10-10 per acre. The fertilizer should be well worked into the soil.

Bromegrass may be used on waterways and outlets, highway shoulders, etc., in the northern one-third of Illinois. Tall fescue (Kentucky 31 or Alta) is recommended for the southern two thirds of the state. Either the bromegrass or the tall fescue should be seeded at the rate of 25 pounds per acre. The tall fescue is better adapted to the poorer soils.

Legumes are not generally recommended on areas of this type. They do not form a tough, dense sod as do the grasses; and with the heavy fertilization that is recommended, the grasses will crowd them out after the first year. The seed should be covered lightly by harrowing.

The same rates of fertilization are recommended for establishing lawns. A straight seeding of 10 pounds of Kentucky bluegrass per acre is perhaps the quickest and most economical way to establish a lawn. In shady areas, however, Chewings fescue at the rate of 10 pounds per acre will be more apt to catch, as it is tolerant to shade.

After the seedbed has been prepared and the seed and fertilizer applied, the area is ready to apply the asphalt. When the soil moisture is near normal, the asphalt may be applied directly. In periods when the surface is dry, the area should first be wet with water to a depth of at least one inch. The asphalt may be applied as soon as the water has disappeared from the soil surface.

The recommended rate of applying asphalt is .2 to .4 gallon per square yard. On level to gently sloping areas, .2 gallon may be ample, while on steeper slopes .4 gallon may be needed to provide adequate protection from erosion. If a rate heavier than .6 gallon per square yard is applied, the material will run. As good growth and stands, or better, have been obtained with the heavy applications as with lighter applications; and they have also equaled those on the check plots, where no asphalt was applied.

The asphalt must be applied in the form of a spray. Sprinkling has been tried, but it is not satisfactory because a thin even coat cannot be applied. The asphalt emulsion can be applied at the prevailing air temperature. The cutback asphalt must be heated before application. It should, however, never be heated above 190° F.,as the heat may injure the seed.

A temperature of 170° F. seems ample. The University of Illinois Physical Plant recently applied some cutback at 140° F. with good results.

In the tests the asphalt emulsion was applied with a three-gallon knapsack or orchard-type sprayer. The nozzle must be reamed out with a drill because the hole in the nozzle that comes with the sprayer is too small to handle this heavy material. This method of application is generally not recommended on areas more than a few yards square.

There are numerous sprayers designed to handle asphalt. They apply the material in the shape of a fan and do a good job of application. The University of Illinois Physical Plant has a small two-wheeled trailer-type sprayer that holds about two barrels. It will handle either the emulsion or cutback. It was purchased from the Aeroil Products Co. of Chicago, Illinois. Division highway garages often use similar equipment in patching roadways. In two cases we have applied emulsion with a garden hose. The hose was attached to a small compressor mounted directly on the tractor power takeoff. The barrel was mounted on the tractor and an intake hose was run directly from the compressor into the barrel. With some improvements this method may be practical.

At present, 55-gallon drums are the smallest containers in which asphalt can be purchased. The cost is about 22 cents per gallon in drums and about 12 cents per gallon in tank cars. On a square-yard basis the cost would be approximately 5 to 8 cents. This price compares favorably with a straw mulch and overcomes such disadvantages as fire, blowing, and spreading weed seeds.

The emulsion used in experimental work was supplied by Shell Oil Company, Blum Building, Chicago, Illinois. The cutback was supplied by the Lion Oil Company, El Dorado, Arkansas.

Harold M. Smith
Soil Conservation Service
5-25-53

AGRONOMY FACTS

OKAW BROOMCORN

Origin and development. Okaw broomcorn originated from a cross between Black Spanish broomcorn and Leoti Red sorgo. It was developed by the Illinois Agricultural Experiment Station. The original cross was made about 20 years ago by Dr. John Martin, senior agronomist in charge of sorghum and broomcorn investigations, U. S. Department of Agriculture.

The parents differed in many characters, and consequently there was extreme segregation in the second-hybrid generation. Selection thereafter was made for good brush, tan plant color, and resistance to lodging. Later, under conditions of natural infection, it was observed that some of the progenies had marked resistance to anthracnose stalk rot, and selection was then directed toward intensifying this character. Tan plant color and anthracnose resistance came from the Leoti parent.

Description and performance. Okaw is a standard type. It resembles Black Spanish in height and seed color, but differs from it in having tan instead of red plant color and in being resistant instead of susceptible to anthracnose. Because it has the tan color factor and is disease resistant, it holds its green color longer than other varieties do. The brush will not turn red in the field or shed, and the seed brush compares very favorably with the green brush in color and quality.

These factors should be of great help to growers, especially in western states, since Okaw will produce a good colored brush even if harvested late or under adverse weather conditions.

Okaw compares very favorably with other varieties in brush length and quality. According to results obtained in 1952, the brush runs from self-working to strong self-working. Like other standard varieties, Okaw will produce short brush and some center stem if planted too thick. Some growers who had plantings in 1952 thought it tended to bear seed too far down on the brush. Its yields of both brush and seed seem to compare favorably with those of other varieties.

Okaw matures at about the same time as Black Spanish or perhaps a few days later. It stands well under most conditions, and when anthracnose stalk rot is present it stands much better than other standard varieties.

Seed increase and distribution. Before increase of seed, small isolated plots of this variety were planted. The head-row system was used. The rows were carefully examined before the pollen shedding stage, and any red plants were removed. When the seed was ripe, the heads were sorted, and those with acceptable length of fiber and quality were saved. The strain was designated Ill. No. 1 before the name Okaw was given to it.

In 1951 an isolated increase plot of .8 acre was grown on the Agronomy South Farm. This plot was inspected by the Illinois Crop Improvement Association, and the seed that was produced was later certified. In the spring of 1952, this seed was distributed for further increase to seven growers in the Arcola-Humboldt-Charleston area, who planted it on a total of 104 acres and in turn had the resulting seed crop certified. These Illinois growers, with their addresses, are as follows: Wm. E. Abell, Humboldt; Wm. M. Grant, R. 2, Charleston; Chas. W. Hood, R. 4, Arcola; Geo. Pfeifer, Arcola; W. E. Rennels, R. 2, Charleston; C. E. Shawver, R. 3, Charleston; and Henry Vogel, Arcola.

C. M. Woodworth
Benjamin Koehler
1-11-53

PRODUCING HYBRID CORN WITHOUT DETASSELING

The use of cytoplasmic male sterility may eliminate the need for manually detasseling some 500,000 acres of hybrid seed corn production fields and save seven to eight million dollars yearly. In addition, the need for large numbers of temporary workers will be decreased, and the hazards of unfavorable weather during detasseling will be largely eliminated.

To understand the use of cytoplasmic male sterility for this purpose requires a knowledge of several basic facts. This sterility represents a rare and peculiar type of inheritance that is distinguished by the following points:

(1) The plants produce a normal appearing tassel, but it sheds no pollen; and (2) sterility results from some property in the cell cytoplasm that differs from the ordinary characteristics (kernel color, etc.) that are determined by chromosomes in the nucleus and inherited from both parents.

For an analogy one might think of the "yolk" of a hen's egg as the nucleus and the "white" as the cytoplasm. Since only the ear parent (female) transmits cytoplasm to the offspring, sterility can be inherited only from the ear parent.

Even though sterility results from some property in the cytoplasm, there are genes located on the chromosomes which still control the expression or degree of sterility. For example, two plants may both have sterile cytoplasm, but one is male sterile and the other is male fertile because it carries genes which prevent the expression of sterility.

Male sterility does not normally occur in standard inbreds, such as WF9, and so the sterile cytoplasm must be introduced. This is accomplished by crossing WF9 with the sterile strain and crossing this progeny back to WF9 at least five times.

In the crossing back to WF9, only sterile plants with characteristics of WF9 are used. The resulting male-sterile WF9 is maintained and/or increased for use in seed production by crossing it with the normal WF9, using the male-sterile version as the ear parent. The sterile and normal WF9 differ only in that the former is male sterile.

Fortunately, of the four inbreds used to produce a hybrid, only one inbred must possess male sterility (see Figure 1). A large percentage of the hybrids grown in the Corn Belt have WF9 as a common parent. Hence no detasseling would be required in producing these hybrids with male-sterile WF9 as one line of the ear parent single cross.

The production of hybrid Ill. 1570 without detasseling is shown in Figure 1:

Figure 1. Production of Ill. 1570 Without Detasseling

Ear parent		Pollen parent
Inbred WF9 (Male sterile)	X	Inbred 38-11 (Normal)
WF9 x 38-11 (Male-sterile single cross used as ear parent; does not have to be detasseled)	X	Hy2 x Oh41 (Normal single cross used as pollen parent)

Hybrid seed for farmer

Because of environmental or genetic variation, a small percentage of tassels in the male-sterile ear parent may shed pollen. These tassels must be removed, but that should not serve as a reason for criticizing the hybrid seed that is being produced. Even though some variation in sterility exists, the seed parents may still be uniform for their desirable agronomic characteristics.

Although a high degree of sterility is desirable during the production phases, sufficient pollen production to assure a full seed set is a necessity when a hybrid is grown by the farmer. Adequate pollen shedding in the field may be obtained by (1) producing the hybrid on both male-sterile and male-fertile versions of the ear parent and mixing the seed or (2) using a single-cross male parent carrying genes which counteract the sterile cytoplasm so that pollen production is restored in the resulting crop.

With either method of restoring pollen production, male-sterile plants may appear in the farmer's field. Insufficient pollen shedding may be indicated by scattered seed set on the ears at harvest. However, scattered seed set may result from environmental as well as genetic factors.

A few facts concerning the use of cytoplasmic male sterility to eliminate detasseling, including both the advantages and the disadvantages, are summarized below:

1. In the future most of the hybrid seed corn will be produced without detasseling the ear parent single cross.

2. Seed cost will not be greatly reduced.

3. Cost of detasseling will be eliminated, but breeding work and seed stock maintenance will be more complicated and expensive than at present.

4. Hazards of unfavorable weather during the detasseling season will be lessened.

5. Male sterility in itself will not be likely to improve hybrid performance.

L. F. Bauman
1/12/53

RATE OF PLANTING CORN

Several factors operate to determine the proper rate of planting corn to obtain highest grain yield, but the most important one is the productivity of the soil. The more productive the soil, the greater must be the plant population in order to obtain maximum yield

Thin corn on productive soil will produce large ears, and sometimes single plants will produce two ears. As the number of plants increase on a given area, the amount of grain produced per plant decreases. To a certain point, however, the decrease in production per plant is less than the increase in aggregate yield resulting from the increased number of plants.

When the population is further increased, a point is finally reached where the decrease in ear size is great enough to more than offset the gain accruing from the larger number of ears. The population that produces the smallest ears without reducing the per acre yield is the correct one to use to get the highest yield.

Size of ear, then, is a guide to whether or not corn is planted at the optimum rate for maximum yield. For the central corn belt hybrids, the correct size of ear is somewhere between .45 and .55 pound. In states north of Illinois, the ear size associated with highest yield is smaller than this figure.

With optimum ear size figured as 1/2 pound and plant establishment as 87 1/2 percent of the kernels planted, the chart on the back of this sheet has been constructed as a guide to planting rates for maximum yields.

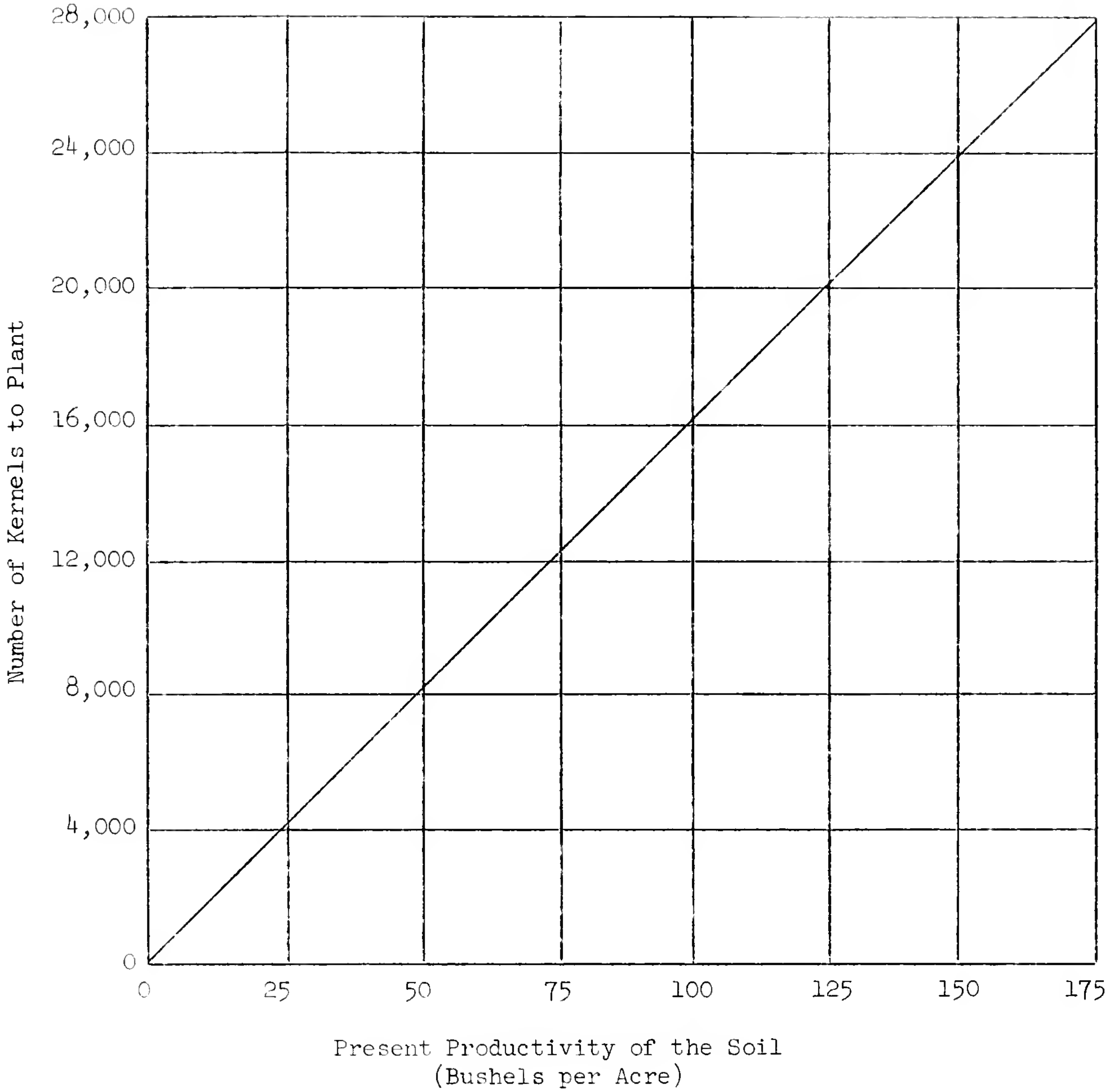
In using the chart the first thing to consider is not how much yield is wanted, but how much the field will produce per acre under moderately favorable conditions. Locate this figure on the scale at the bottom and then look up to the diagonal line. Then from this point look straight to the left to get the number of kernels to plant per acre.

If the corn is checked in rows 40 inches apart each way, planting one kernel per hill will yield 25 bushels per acre on land with that yield capability. For each additional 25 bushels per acre, step up the rate of planting one kernel per hill. For drilled corn, gauge the distance between kernels in the row by the inches obtained when 40 is divided by the number of kernels that would be planted per hill if the corn were checked.

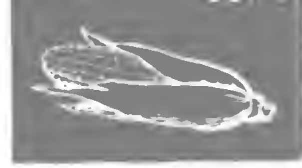
Thickly planted corn has more slender stalks than the same kind of corn in a dense stand. The result is more plants on the ground at harvest than would otherwise be the case. Corn planted at high rates produces smaller kernels as well as smaller ears and also a lower percentage of flat, blocky kernels than the same hybrid planted at lower rates on soil of the same productive level.

Moisture supply and distribution have an important effect on soil productivity. A field that under favorable moisture conditions has a productive level of 150 bushels per acre might be lowered to a 75-bushel capacity by drouth. If it had been planted at the rate of 24,000 kernels per acre in an attempt to get the 150 bushels, the dry season would be likely to pull the yield down below the 75-bushel level. Overplanting will harm corn yield just as underplanting will. A high yield cannot be attained without a large corn plant population, but a large number of plants per acre is no guarantee of high yield.

G. H. Dungan
4/20/53



28,000
24,000
20,000
16,000
12,000
8,000
4,000
0
Number of Kernels to Plant
0
25
50
75
100
125
150
175
Present Productivity of the Soil
(Bushels per Acre)



AGRONOMY FACTS

C-3

STEWART'S DISEASE LEAF BLIGHT AND NORTHERN LEAF BLIGHT OF FIELD CORN

Symptoms. These two diseases are discussed together because often it is not possible to distinguish between them by the appearance of the lesions on the leaves, especially when only a leaf or two are sent in for identification.

Although these diseases can be identified by observing characteristic lesions, not all lesions are characteristic. Typically Stewart's disease (also called bacterial wilt) infection, caused by Bacterium stewartii, travels along the veins, causing first a pale green and then a straw-colored appearance of the adjacent affected tissues. The spreading-out at right angles to the vein is irregular in outline, appearing first as long, narrow streaks along the vein, with irregular margins. In the advanced stages it sometimes becomes an inch or more wide. Several local infections on a leaf may kill the entire leaf.

Usually in field corn this leaf infection is the principal symptom, there being no wilt as is sometimes noted in young susceptible sweet corn. In field corn in Illinois, both diseases usually become conspicuous only after pollinating time.

Northern leaf blight, caused by the fungus Helminthosporium turcicum, appears typically as elongated eliptical lesions, more or less bluntly pointed at both ends. These pointed ends may be on the veins, but usually there is not a long linear extension along the vein. The lesions start as very small spots, becoming 3 to 6 inches long and 1/2 to 1 inch wide. When there is a considerable amount of infection, a number of lesions may coalesce before they become this large, giving a very irregular outline to the infected area.

The most definite symptom is the development of darker eliptical sporulating areas in the central part of the lesions after they are several weeks old. A microscope is needed to identify the spores accurately. In damp weather areas killed by Stewart's disease may also develop a dark fungus growth. A saprophyte, usually an alternaria species, grows on the dead tissue.

In both diseases, after the leaves become badly blotched from infection, the remaining green leaf tissue begins to die. This is especially true where the soil does not contain enough potassium. This unbalanced condition may also have a direct effect in increasing susceptibility. Sorghum or broomcorn growing nearby may give a clue to the identity of the blight, as these crops are susceptible to northern leaf blight but immune to Stewart's disease.

Factors determining infection. The bacteria causing Stewart's disease live over winter in the bodies of flea beetles, and the disease is carried to corn plants by the feeding of these insects. The late N. E. Stevens, former head of the Botany Department, University of Illinois, found that winter temperatures affect the carryover of the disease. Ordinarily, when the sum of the mean temperatures for December, January, and February is 90 or less, there is no likelihood that Stewart's disease will occur the following season: when it is between 90 and 100, the chances are that there will be moderate infection; and when it is 100 or over, the disease may be serious.

Another factor is the prevalence of the disease in the previous season, as it tends to build up with repeated favorable seasons. So far as is known, weather conditions during the summer have little influence on the disease.

Northern leaf blight requires high humidities during the growing season. Winter temperatures, so far as is known, are of no importance. The fungus lives over winter on corn refuse, and the spores are carried to the new corn crop by the air. In this case, also, the disease tends to build up after several favorable seasons. This accounted for the unusually heavy damage in Illinois in 1951. Higher summer humidities and more damage from northern leaf blight occur on the average in states to the east of us.

Relative importance. Some lesions of both of these diseases can be found on corn leaves somewhere in Illinois in every season. Infection severe enough to cause damage occurs most frequently with Stewart's disease, especially in south-central Illinois. Northern Illinois is relatively free from Stewart's disease.

Damage caused by both of these diseases is aggravated by both Diplodia and Gibberella stalk rot. The reason is that anything that causes severe loss of effective leaf surface while the ears are very immature increases stalk rot susceptibility.

The end result of leaf blight and stalk rot together has occasionally caused a 50 percent loss in yield on some Illinois farms. Ordinarily Stewart's disease and northern leaf blight are the two principal leaf diseases in Illinois, but under unusual conditions other pathogens, such as Helminthosporium maydis, H. carbonum, Leptosphaeria maydis, etc., or rust may cause serious leaf blight.

Control. Resistant varieties are the principal requirement for control. It has already been mentioned that unbalanced soil fertility aggravates the effects of these diseases, but even on the best soils either one may cause severe loss. In a year when an epidemic occurs, the most susceptible varieties can be recognized, and the hybrids most susceptible to Stewart's disease are no longer grown in areas of Illinois where damage can be expected frequently. But for a breeding program to develop a high degree of resistance in combination with other desirable agronomic characters, it is necessary to have some assurance of an epidemic of the disease in the breeding plot every year. To obtain this condition, breeders have used two approaches.

One method is to inoculate the plants in such a way as to obtain an epidemic. The other is to plant the breeding plot at a geographical location where the disease is very damaging and recurs consistently.

With Stewart's disease neither of these methods has yet worked very well. Inoculation methods on an extensive scale have not been developed. Insect transmission is involved. Simply spraying the plants with the bacteria is not successful. The result is that for the most part hybrids are being used that have only a moderate degree of resistance and considerable damage occurs when the disease becomes heavy.

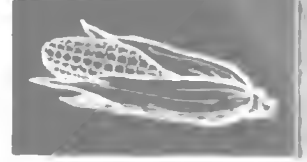
Breeding for better stalk rot resistance, is, however, making some headway and will reduce the final damage resulting from the Stewart's disease—stalk rot combination.

In northern leaf blight, both methods of breeding have been used successfully. Inoculation methods have been developed and are being widely used. Corn grown during the winter and spring in parts of Florida or Central America are usually subjected to natural epidemics. The result is that encouraging progress toward the breeding of resistance to northern leaf blight has been made.

Benjamin Koehler
9/1/53

UNIVERSITY OF ILLINOIS · COLLEGE OF AGRICULTURE

AGRONOMY FACTS



DRYING CORN GRAIN AT HIGH TEMPERATURE LOWERS ITS VALUE FOR PROCESSING

About 80 percent of the corn kernel is starch. The other 20 percent is made up of gluten (protein), the germ, and the hull. The hull and the germ are well defined parts of the kernel. The starch and gluten are not so clearly distinct from one another. Just under the hull is a thin layer known as the aleurone, which is predominantly gluten. On the sides of the kernel and extending toward the center is horny material consisting of a mixture of gluten and starch. Filling the crown of the kernel and extending downward around the germ is the white, starchy part. This is not wholly starch, however, as it contains some protein and a little oil.

In the processing of corn by the wet milling method, the kernels, after being sifted and cleaned, are first soaked in water for 36 hours. The soft kernels are then run through the degerminating mills which spread and tear the corn into pieces without crushing the germs. Being high in oil, the germs float to the surface of the tank, and the other constituents, being heavier than water, settle to the bottom. It is an easy matter, therefore, to separate the germs from the rest of the kernels.

Separating the starch from the gluten is a more difficult process, as starch is only slightly heavier than gluten. The material, after being finely ground, is made into a thin soup by the addition of a large amount of water. The starch and gluten mixture, which looks like rich milk, flows onto the starch tables that are long, flat-bottomed, shallow troughs. These starch tables slope just a little to make the flow of liquid very gradual and to give the starch granules plenty of time to settle out from the gluten.

This works very well with normal corn, but difficulty may arise if the corn has had some abnormal treatment. Here is where high drying temperatures cause trouble. Heat above a certain point tends to cause starch and gluten to cling together more tenaciously.

Cooperative tests made by the Northern Regional Research Laboratory, Peoria, and the Departments of Agricultural Engineering and Agronomy, Illinois Agricultural Experiment Station, Urbana, show that drying wet corn at high temperatures interferes with the clear-cut separation of starch from gluten. For instance, when soft corn containing 66 percent moisture was dried at 180° F., the recovery of starch was only 57 percent; but when a sample of the same corn was dried at 110° F., the recovery of starch was 72 percent.

What became of the starch in the sample dried at the high temperature? A large part of it came out with the protein. Here are the results: The gluten separated from the sample dried at 180° F. was 57 percent starch, and that from the sample dried at 110° F. was only 36 percent starch. Drying at a high temperature also caused a relatively high percentage of starch in the fiber fraction.

Since a high yield of starch is vital to the success of the wet milling industry, it is no mystery why processors object to artificial drying of corn. One corn refinery will not buy any corn for processing if it is known to have been dried by heated air. Most companies believe that if the temperature of the drying air has not exceeded 135° F. the corn will not be harmed. If the corn is to be used for livestock feed, drying temperatures may be higher than 135° F.

In order to determine more definitely the effect of drying on the processing quality as well as the feeding value of corn grain, experiments are being continued by the Departments of Agricultural Engineering, Animal Science, and Agronomy in cooperation with the Northern Research Laboratory. Drying corn by heated air is looked upon as a practice that will increase in the Corn Belt, and its effects on the grain should be fully known.

G. H. Dungan
9-14-53

CORNSTALK ROT DISEASES

A number of parasitic fungi and one bacterium have been observed to cause cornstalk rot. On the average, stalk rot has been the most important disease of corn in Illinois. In certain cases, however, some other diseases have far surpassed it in causing losses.

Stalk rots are important because they occur very frequently, causing serious lodging and often losses in yield. Lodging is very detrimental because the ears that contact the ground deteriorate during wet weather, and the corn picker leaves many ears of lodged plants in the field.

DIPLODIA STALK ROT is the most prevalent type in Illinois. It is caused by the fungus *Diplodia zeae*. The same fungus also causes ear rots, but it does not attack any other crop plants. Stalk infection does not start to develop until several weeks after pollination, and most of it usually starts later than that.

The lowest 6 to 12 inches of the stalks usually rot worst, but local infections at the nodes may also occur higher up. Infections may start at the junction of the main roots with the stalks just below the soil, at the junction of the brace roots, or at the junction of the leaf sheaths or axillary buds or ear shanks at the nodes.

In aboveground infections dark brown streaks or areas, seen on the surface of the stalks, extend down, or both up and down, from the place where infection started. On the interior of the stalks, the rot may spread far beyond these discolored areas. The interior becomes retted and hollow, but there is little discoloration. When squeezed, the stalks usually feel soft where the rot is well advanced.

When Diplodia rot takes place comparatively early, plants may start to die prematurely in late August. Soon after they die, the fungus usually starts to fruit, and it is only from these fruiting bodies that the disease can be identified in the field.

The fruiting bodies can first be seen as tiny black points, ranging from 300 to 1,000 per square inch, just beneath the surface of the stalk. The fruiting area may be either less or considerably more than a square inch. As the bodies mature, they break through to the surface.

Diplodia rot does not attack plants until translocation of food materials to the ears becomes active. Plants that fail to develop ears remain immune. Too little or too much potassium in the soil may increase the susceptibility of plants to Diplodia rot. Premature killing of leaves from various causes, such as disease, insects, or frost (but not drouth) increases susceptibility to both Diplodia and Gibberella stalk rot.

Inoculation techniques for producing artificial epidemics of Diplodia rot have been developed successfully and are useful in breeding for resistance. Data on differences among hybrids dying prematurely from stalk rot (primarily Diplodia rot) are given from time to time in bulletins published by the Illinois Agricultural Experiment Station.

The ranking of hybrids, however, is not always the same. In one year stalk rot susceptibility may be aggravated by leaf blight from Stewart's disease. At another time it may be promoted by northern leaf blight, while at still another time it may be due to other causes. Thus the resistance of a hybrid to these predisposing factors is as much a part of the end result as is its innate resistance to Diplodia stalk rot.

GIBBERELLA STALK ROT is, on the average, the second most prevalent type in Illinois. It is caused by the fungus Gibberella zeae, which may also cause ear and root rots. It also causes scab in small grains and attacks the roots of several other crop plants besides corn. In 1946 and 1951, Gibberella caused more cornstalk rot in the state than any other pathogen. But the cause and severity of stalk rot always varies considerably from place to place. Damage occurs after midsummer and in the fall.

The symptoms, including discolorations, location of rot, and loss of firmness, are practically identical with those of Diplodia rot. When the stalks are cut open after the rot has gone far enough to kill the plants, one is likely to see a limited amount of pink coloration, but this color does not usually occur throughout the rotted area.

This fungus may also fruit on the surface of the stalks. With a good hand lens, an experienced person can make a fairly accurate identification in the field. As in Diplodia, the fruiting bodies are black, but they are borne entirely on the surface of the stalk, where they can be scraped off with a fingernail. They also tend, to a greater extent than in Diplodia, to bunch at the nodes of the stalk. Any of the fungus rots that are not fruiting or that do not show definite diagnostic symptoms may still be identified by using suitable laboratory techniques.

Giberella stalk rot appears to be most prevalent and destructive on highly productive soils that are rich in nitrogen. With the trend toward heavier fertilizer applications, the need for breeding more resistant hybrids seems evident. No good method for producing artificial epidemics to aid in the breeding program has yet been developed.

CHARCOAL ROT is caused by the fungus Sclerotium bataticola, which also attacks the stems and roots of many other plants besides corn. It causes most damage in hot and moderately dry weather and ordinarily is more prevalent farther west and southwest than in Illinois. It also occurs oftener in southern than in northern Illinois, but damage is light in normal seasons. In the hot summer of 1953, however, infection was unusually high.

This rot is usually limited to the lowest 8 inches of the stalk, which may disintegrate badly, causing plants to fall as they approach maturity. The disease can be easily identified in the field by the presence of tiny black dots that look somewhat like fine charcoal dust. They are especially noticeable on the inside of the stalk, on the loose fibers of the vascular strands which are all that remain in badly rotted stalks. These dots are much smaller and more numerous than those of Diplodia or Gibberella, and they occur especially in the interior of the stalk, while those of Diplodia and Gibberella occur only on the exterior.

PYTHIUM STALK ROT is caused by the fungus Pythium butleri. Unlike the rots described previously, it is active only during the heat of midsummer and may occur even before pollinating time. It requires moist weather. It is a dark, soft rot, usually not more than 3 to 6 inches long, near the bottom of the stalk. The plants fall while they are still completely green, retaining their green color for several days afterwards. This indicates that the infection, after gaining a foothold, works very fast. Fortunately the disease occurs only sporadically.

BACTERIAL STALK ROT is reported to be caused by Bacterium dissolvens. The description of Pythium stalk rot applies also to this disease. Since it does not seem likely that there would be two diseases that look and behave exactly alike, more study of the causes appears necessary. Up to now the situation is puzzling, because specimens collected by the writer from a number of fields showing these symptoms readily produced colonies of Pythium butleri by laboratory techniques, while specimens from just as many other locations produced only bacteria resembling Bacterium dissolvens.

Benjamin Koehler
12-7-53

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AGRONOMY FACTS

C-6

EFFECT OF TIME OF PLANTING ON YIELD OF CORN

Sometimes the weather forces farmers to plant corn late. At other times they plant late from choice. No matter what the reason may be, they need to know the effect of planting at different dates on yield, on percentage of moisture in the grain, and on capacity of the plants to remain erect until harvest.

The Illinois Agricultural Experiment Station has conducted tests at Urbana on time of planting corn through nine seasons. Three hybrids were used, one adapted to northern, one to central, and one to southern Illinois. So far as conditions would permit, six planting dates 7 to 9 days apart were used. The first was May 3, 4, or 5. In five of the nine years, soil conditions permitted plantings on the desired dates without any skips. The data from these five years have been averaged and are presented in the table below:

Average Yield of Grain, Percentage of Moisture in Grain at Harvest Time, and Percentage of Plants Erect When Harvested, for Three Corn Hybrids Planted at Six Different Dates, Urbana, Illinois (1944, 1945, 1950, 1951 and 1952)

Average date of planting	Yield of grain	Moisture in grain at harvest[a]	Plants erect when harvested[a]
	bu./A	perct.	perct.
May 4	112	18.3	80.4
May 12	108	19.5	79.5
May 19	111	20.7	78.4
May 27	110	21.5	69.6
June 3	101	23.5	66.6
June 12	89	25.5	54.0

a/ Data for 1952 are not included in the averages shown in this column.

In this table the grain yield showed a drop for the May 12 planting, but it is believed to have been due to chance. The "meat" in these data is that yield is high for all plantings made in May. A significant drop in yield did not occur until the June 3 planting. And the June 12 planting produced only about 80 percent as much grain as the May 4 planting. In this experiment harvesting was always postponed until late November or early December to allow the sappy ears to dry out. But even this delay was not always enough to bring the moisture in the kernels of corn planted on May 27 down to the 21 percent that is considered safe for cribbing. So, even though our modern corn hybrids are capable of

maintaining high yields when planted in late May, the hazard of wet corn is a real one for the grower who elects, through choice or otherwise, to plant late in May.

Stalks stand a little better when the crop is planted early, although there was not much difference between the percentages of erect plants from plantings made on the three first dates in May. Stalks that do not reach full maturity in the normal growing season lack the stiffness required to resist the strong winds of late autumn.

Another factor that may play a part here is the height of the plant. In some years late-planted corn grew significantly taller than that planted early. The extra height of plant and the heaviness of the immature tissue in the green stalk handicapped the corn in the late-planted plots when it came to a test of lodging resistance.

The results obtained at Urbana were duplicated in an experiment conducted by Ray Dunn in Henderson county, Illinois, in 1951. He used the same three hybrids and the same six planting dates. In addition to finding the same general trends in yield and moisture content as were obtained in the experiments at Urbana, he found a striking difference in hybrids with respect to time of planting.

The late-maturing hybrid yielded distinctly more grain than the early one at the first planting. At the last planting, the yields were not widely different, but the grain of the early hybrid contained 5 percent less moisture than that of the late one. These results emphasize the wisdom of the common practice of using a short-season hybrid for late planting.

In all of these tests, stand of corn did not influence the results. The hills harvested for yield were perfect, and they were bordered by hills that had at least two stalks in them. The experiment was designed to find out what effect time of planting might have on the productiveness of corn plants and not to see what effect it might have on stand.

By way of summary it may be said that in central Illinois tests with early, mid-season, and late hybrids (1) the yield of grain was not significantly reduced by plantings made as late as May 27 compared with plantings made earlier in May, (2) the yield of grain was significantly reduced by plantings made in June, (3) the moisture content of the grain at harvest time increased with lateness of planting, and (4) the percentage of plants standing erect at harvest decreased with lateness of planting, particularly those plantings made after the third week in May.

George H. Dungan
2-8-54

SELECTING AFLAFLA VARIETIES

Two main points to consider in selecting an alfalfa variety are (1) time you expect the alfalfa to stand before plowing it down and (2) cost of seed. If you will use the stand several years for hay, plant certified seed of a winter-hardy, wilt-resistant variety, such as Ranger or Buffalo. If you will use it only one or two years for hay, plant a winter-hardy, wilt-susceptible variety, such as Kansas Common.

Bacterial wilt does not reduce alfalfa yield until about the third year. Because the common alfalfas are as productive as Ranger and Buffalo the first year or two,there is no advantage in using the more expensive seed in short rotations.

Several varieties of alfalfa have been developed in the United States. There is a good seed supply of certain varieties but not of others. Following are descriptions of available varieties and the acreages of seed fields certified to each in 1952:

Ranger, which is resistant to bacterial wilt, was developed by the Nebraska Experiment Station by intercrossing selected strains of Cossack, Ladak, and Turkistan. A good forage and seed producer, Ranger is as winter-hardy as the most hardy common alfalfa. The flower color is variegated. 110,370 acres of seed fields were certified this year.

Buffalo, also resistant to bacterial wilt, was developed by the Kansas Experiment Station out of Kansas Common. A good forage and seed producer, it is only slightly less winter-hardy than Ranger. Flower color is purple. 30,893 acres of seed fields were certified.

Atlantic, a high-yielding variety developed by the New Jersey Experiment Station, is not resistant to bacterial wilt. Developed especially for the eastern states, where bacterial wilt is not serious. It is about as winter-hardy as Buffalo. Flower color is variegated. 4,219 acres of seed fields were certified this year.

Narragansett, a high-yielding variety developed by the Rhode Island Experiment Station, is not resistant to bacterial wilt. It was developed for use in the eastern United States north of the area where Atlantic is adapted. Flower color is variegated. Seed will not be available in 1953.

Nomad has a high proportion of creeping plants that will root at stem nodes. It is from an old field in Oregon found to have this type of plant. Nomad is susceptible to bacterial wilt and has not been tested enough to determine its adaptability. In most tests it has not appeared to be so vigorous as other varieties. Because of its creeping habit of growth, it may be useful in pastures. A limited amount of seed is available commercially.

Talent was selected in Oregon from a strain of common alfalfa introduced from France. It is resistant to stem nematode, which is not serious in Illinois. It is not resistant to bacterial wilt and does not appear to be so winter-hardy as Buffalo. It has a purple flower. Only a limited amount of seed is available commercially.

Ladak, introduced from northern India, is more cold- and drouth-resistant than Grimm. It recovers slowly after cutting,

begins growth late in the spring, and becomes dormant early in the fall. First-cutting yield is usually larger than that of other varieties,and second- and third-year cuttings are smaller. Total seasonal yield is about the same as for Ranger and Buffalo. Ladak is somewhat more tolerant of bacterial wilt than the common alfalfa, but it is not so resistant as Ranger and Buffalo. Flower color is variegated. 25,872 acres of seed fields were certified in 1952.

These varieties, except Ranger, Buffalo, and Ladak, have not been tested long enough in Illinois to determine their merit. Because of susceptibility to bacterial wilt, Narragansett, Atlantic, and Talent should be used only in short rotations. But even before they are used for this purpose, they will have to prove superior in yield to Kansas Common and other common varieties now used. The creeping habit of Nomad might make it desirable in pastures, but its susceptibility to wilt will probably make it less desirable than Buffalo and Ranger for this purpose.

Certified seed of Ranger and Buffalo is produced outside the region of adaptation of these varieties, principally in California. For seed to be certified under such conditions, the seed fields must be established from seed produced in the region of adaptation.

Seed fields can remain down only six years; therefore certified seed of Ranger and Buffalo produced in California is only one generation removed from plants that grew in the region of adaptation. Also, in fields growing certified seed, precautions must be taken to prevent the growth of volunteer seedlings. Winter-hardiness studies have shown that, when these precautions are taken, there is only slight loss of winter-hardiness. It is only when these varieties are grown for two or more generations outside the region of adaptation that there is serious loss of winter-hardiness.

J. A. Jackobs
1/12/53

NONHARDY ALFALFAS

Except for certified Ranger and Buffalo alfalfa, the adaptation and performance of alfalfa varieties or strains in Illinois can be predicted by state or region of origin.

The term hardy has been assigned to varieties or strains originating in the northern part of the United States, such as Minnesota, Montana, and the Dakotas.

The common strains originating in the central area, such as Oklahoma, Kansas, Colorado, and Utah, are considered less hardy than those from farther north, but they are sufficiently winter-hardy to use in short rotations in Illinois.

Strains or varieties grown in the warmer sections, such as Texas, New Mexico, Arizona, and California, are considered to be nonhardy in Illinois.

For catch-crop purposes in Illinois, the nonhardy varieties, Arizona Common, California Common, Chilean, African, Indian, and Peruvian are preferred. Texas and New Mexico produce some seed that will approach Oklahoma approved seed in winter-hardiness, as well as some that is nonhardy. Winter-hardiness of Texas Common and New Mexico Common depends entirely on previous history and altitude at which they originated.

Sweet clover is probably in a class by itself as a catch-crop legume, but its use for this purpose has declined rapidly in Illinois because of the sweet clover weevil and root rot. Where root rot is not a factor, farmers should be encouraged to continue to use sweet clover, and the insecticide necessary to control the weevil, in preference to using other legumes as a catch crop.

If the use of sweet clover is not practical, the nonhardy alfalfa strains or varieties can be substituted. They are preferable to the more winter-hardy types because they make more top and root growth during the seeding year.

Demonstration plots throughout the state have shown the superiority of the nonhardy strains in this respect. Observations show that they may produce two to three times as much top growth as the hardy by fall of the seeding year.

Recent experiments at Ohio indicate that Ladino may also be used as a catch-crop. But in Illinois alfalfa is preferable because it is more drouth resistant. Ladino does, however, make a good addition to nonhardy alfalfa.

One-half pound of Ladino will increase seeding costs very little. If dry weather occurs, the loss is small. If the season is favorable, the Ladino may increase the value of the catch-crop. Since there is always a possibility of losing nonhardy alfalfa over winter, the addition of Ladino may provide green material to be plowed down in the spring.

Nonhardy alfalfa to be used for a catch crop should always be seeded at the heavier rates. The Ohio station reports that seeding rates above 8 pounds have little effect on hay yields. But planting at rates up to 15 pounds produces more dry matter by the fall of the seeding year.

It is true that alfalfa cannot be grown on all soils in Illinois. But where it is adapted, the nonhardy strains should be first choice as a substitute for sweet clover as a catch-crop because

they make more top and root growth than the hardy strains.

Results of an Ohio experiment (see table below) show that hardy alfalfa compared favorably in value with sweet clover as a catch crop. It is logical, then, to assume that the nonhardy strains which make more growth will be of greater value as catch crops.

In this test, covering a period of 14 years, the legumes were compared in a rotation of corn, oats (legume). All straw and stover was removed, and 200 pounds of 0-20-0 was applied each year.

The soil where the experiment was conducted needed potash. This fact may be seen by comparing the results when the straw and stover were left on and when they were removed. Although potash was not applied to the soil on which the alfalfa and other legumes were grown, it can be assumed that the benefits to these crops from potash would have been comparable to those shown for sweet clover.

W. O. Scott
1/12/53

Effects of Using Various Legumes as Catch Crops
Wooster, Ohio, 1930-43

Legume	Increase	
	Corn	Oats
	bu/A	bu/A
Without potash		
Medium red clover	8.0	2.9
Mammoth red clover	10.7	4.0
Alfalfa*	13.1	5.4
Sweet clover	13.3	2.4
With potash		
Sweet clover plus stover and straw containing 70 pounds of potash	29.8	9.5

*Hardy strains used.

BIRDSFOOT TREFOIL

Many livestock men are enthusiastic about birdsfoot trefoil because it can apparently be used to graze cattle without danger of bloat. Livestock gains and milk production have been equal to those obtained with other good legumes.

Birdsfoot trefoil does not become coarse so early in the season as alfalfa. For this reason it can be used for grazing in June and again in July or August by rotating the pastures.

Plants in bloom have a protein content of 20 percent; calcium, 1.1 percent; phosphorus, .28 percent; and potash, 1.1 percent.

Species. Of several species tested in Illinois, the broadleaf type (L. corniculatus L.) has proved to be best. There are two strains of the broadleaf species. One, a native of England that has become adapted to New York conditions during the past 75 years, is commonly referred to as the New York strain. The other, native to the southern European countries, is commonly known as the Italian or French strain.

Empire, an improved variety of the New York strain, was selected by the Cornell Agricultural Experiment Station. Viking, also selected by Cornell, was derived from the Italian strain. Other varieties of Italian origin are Cascade and Granger, both selected in the Northwest. Each of these new varieties will be tested in Illinois as soon as possible.

Characteristics. Birdsfoot trefoil will grow throughout Illinois on many types of soil. It is more drought resistant than red clover and less sensitive to poor drainage than alfalfa.

The Italian species has more seedling vigor, blooms earlier in the spring, and grows more upright than the New York type. However, the New York strain is longer lived than the Italian under grazing conditions. Because the New York strain is better able to survive the effects of grazing, it is recommended for use in perennial pastures. The Italian appears to be satisfactory for meadows that will be cut for hay.

Both strains are perennial legumes that have a deep-growing, branching taproot. The leaves have five leaflets instead of three, as in clover and alfalfa. The flowers are bright yellow and shaped like a pea flower. When the crop is ripe, the seed pods are long, cylindrical, and brown, and they extend outward from the tip of the flower stem like a bird's foot. The pods shatter easily when ripe. The seed is small, rounded, and brownish in color, and there are about 400,000 to a pound.

Management. Here are a few suggestions for establishing and maintaining a stand of birdsfoot trefoil:

Lime the soil, as needed several months before seeding, and start preparing a seedbed at that time. Prepare a good, firm, grass-free seedbed, and leave a light mulch on the surface if possible. Use liberal amounts of a complete fertilizer, such as 10-10-10, according to test. Inoculate with special birdsfoot trefoil culture.

Seed early in the spring in northern Illinois and during the first week in August in southern Illinois. Pack the soil with a corrugated roller before and after seeding. Use about five pounds of

seed per acre, and plant about one-half inch deep. Do not plant with "shotgun" mixtures of other legumes. Birdsfoot trefoil can be seeded with a grass, such as four pounds of bromegrass per acre in the north or four pounds of orchard grass in the south.

The Italian strain is satisfactory for hay production, but the New York is superior for perennial pastures. A grain crop (not rye) may be planted with it to hold weeds in check and reduce soil erosion, but the grain should be planted at the rate of about one-half bushel per acre and should be grazed when six to eight inches high. Grazing and mowing during the first year will avoid shading and competition to the birdsfoot seedlings.

If the plants are protected from grazing during September, they will yield better the following season. Rotation grazing of established stands results in higher yields than continuous close grazing.

Harvesting. The hay crop of birdsfoot trefoil can be cut at the early bloom stage and handled like alfalfa.

Seed is usually harvested from the first crop of the season. On old fields the second crop will usually produce a good seed yield in Illinois if the first crop is harvested in late May. The seed ripens unevenly. Many flowers are still open when the first pods ripen. The pods shatter easily as they ripen. For this reason care must be taken in handling to prevent excessive losses.

One method of harvesting that has given satisfactory results in some cases is to mow with a windrowing attachment when many of the pods are light brown. As soon as the forage is dry enough, it is either placed in a stack or in small cocks or is baled in round bales. Upon drying, it is threshed with a clover huller or a combine.

History. Birdsfoot trefoil was first found in this country near city dumps in New Jersey and New York in 1877. The seed was probably introduced with packing materials from England.

In 1929 a small planting was established on the University South Farm. Several years later that area was converted into a bluegrass border along a new roadway. Although it was mowed repeatedly for twenty years, many trefoil plants can still be found with the bluegrass.

In the spring of 1942 a pasture planting of New York strain was established on an eroded Clarence silt loam near Pontiac, Illinois. Besides maintaining an excellent stand for the past ten years, this planting has been spreading into the bluegrass next to it.

Numerous plantings have been made on both University and private land in Illinois since 1943.

Joseph J. Pierre
Agronomist, Nursery Division
Soil Conservation Service
1/12/53

STRAINS OF BROMEGRASS

Bromegrass strains have been divided into two categories--southern and northern. The southern type is recommended in Illinois because it is superior to the northern type in resistance to both drouth and heat. These superior characteristics pay off in higher yields and better and longer stands.

Table 1 below shows the results of an experiment conducted by the late Doctor R. F. Fuelleman on the Agronomy South Farm with commercial seed of eight bromegrass strains seeded in 1941. These data do not give the entire picture, however. On November 20, 1945, Doctor Fuelleman made a botanical analysis, the results of which are given in Table 2.

The Montana, Utah, Parkland, Minnesota, and Washington strains are classed either as northern types or between the northern and southern types. The Illinois strain is a selection from Achenbach. Both it and the Kansas and Nebraska strains are southern types. The Nebraska strain used in this experiment, which was a commercial seed lot, was probably not so true a southern type as we would expect certified Lincoln to be. However, in this analysis Illinois, Kansas, and Nebraska were the only strains that approached a full stand of bromegrass. Also the weed content was zero in the Illinois and Kansas strains and very small in the Nebraska strain.

An experiment recently established by Doctor Jackobs with pure seed of several different varieties and strains of bromegrass shows the same trend in superiority for the southern types. It is not confined to central and southern Illinois, as evidenced by results from Wisconsin showing that the southern type of bromegrass produced higher yields of hay and pasture than the northern type under their conditions.

Because the seed supply of the southern strain is likely to be limited, it will be necessary to make substitutions when

Table 1.--Yields of Dry Matter From Bromegrass Strains - S-200, Agronomy South Farm, Urbana, Illinois

Strain	Season and yields 1942	1943	1944	1945	1946	5-year average
	lb. per acre					
Kansas	5 735	6 047	5 302	5 152	4 848c/	5 417
Illinois	7 076	5 671	4 813	4 609	3 732c/	5 180
Nebraska	5 134	5 037	4 792	4 628	2 988a/	4 516
Montana	5 428	4 123	4 657	4 898	3 564a/	4 534
Utah	5 497	4 743	4 415	5 390	3 150a/	4 639
Parkland	5 718	4 330	3 326	4 167	1 842b/	3 877
Minnesota	5 745	3 716	3 592	4 102	1 812b/	3 793
Washington	5 901	3 883	4 053	4 121	2 916b/	4 175

a/ Less than 40 percent bromegrass, rest Kentucky bluegrass.
b/ Less than 10 percent bromegrass, rest Kentucky bluegrass and weeds.
c/ Over 90 percent bromegrass.

supplies are short. We therefore suggest that you recommend the following procedure to growers in your county:

1. Use only southern-type bromegrass in permanent pastures to be left down for many years.

2. Stretch the seed supply by seeding at lighter rates in legume-grass mixtures.

3. In pastures to be left down for only two or three years:

   a. Use timothy if it is available.

   b. Use orchard grass if you are willing to manage it properly.

   c. Northern-type bromegrass can be substituted for southern on a limited scale in the north and the north-central part of central Illinois, but we recommend that you do not go "all-out" in suggesting its use in this section.

   Do not use northern-type bromegrass in southern Illinois. Under certain weather conditions it will not become established or after establishment may disappear rapidly.

Table 2.--Botanical Composition and Bare Space on Bromegrass Strain Test Plots

Strain	Species and percentages						
	Bluegrass	Redtop	Bromegrass	Alfalfa	Clover	Weeds	None
Kansas	4	0	96	0	0	0	0
Illinois	0	0	100	0	0	0	0
Nebraska	2	2	70	0	0	16	10
Montana	12	6	40	0	16	20	6
Utah	4	0	48	0	6	26	16
Parkland	16	2	24	0	10	36	12
Minnesota	8	0	44	2	8	28	10
Washington	22	0	44	0	8	26	0

W. O. Scott
1/12/53

EFFECT OF SEED TREATMENT ON SMALL-SEEDED LEGUMES

Treating the seed of small-seeded legumes with certain fungicides will protect the young seedlings from what is called pre-emergence damping-off. That is, the plant is protected from attack by fungi until about the time it appears above-ground. After it breaks through the soil, it has grown away from the protected area around the seed. Therefore, the only effect of seed treatment is to increase the number of plants that come up when pre-emergence damping-off is present.

It is known that pre-emergence damping-off does occur in forage crops,but there is little evidence that it causes poor stands. One reason may be that it is most severe in the small-seeded legumes when the soil is warm and moist. Most of our spring-seeded legumes are planted as early as possible in the spring when the soil is cold and wet and there is a minimum of damping-off. Alfalfa seeded in August is planted in warm soil, but at this time of year the surface soil is usually dry, and this dryness would probably control damping-off.

Field tests conducted by various experiment stations have given results that vary from slight decreases to slight increases in stand with treatment. The over-all average shows a slight increase with treatment. From a practical standpoint, what do these results mean?

Tests with different planting rates show that the number of plants in a stand may vary a great deal without affecting yield. A thinner stand produces larger plants that in turn produce just as much forage as a thicker stand of smaller plants. Increasing the stand by only a few plants through seed treatment is therefore probably of little or no practical significance in increasing yield. At this point one might ask this question: If seed treatment increases emergence, then can't rate of seeding be reduced?

That is doubtful. Most farmers use a very high seeding rate. They do it because there are many hazards that may prevent the seed from germinating or kill the seedlings. Pre-emergence damping-off is only one of these hazards, and probably not the most important one. If the surface soil dries out just as the seed germinates, causing a poor stand, seed treatment actually increases the damage. There are other hazards that seed treatment cannot overcome, and a high seeding rate does provide some insurance against most of them.

Now, what about using seed treatment as insurance against heavy loss from pre-emergence damping-off when treatment means the difference between a thin, weedy stand and a good stand?

This reason is the best argument for treating legume seed. Seed treatment is relatively inexpensive; and even if such losses occur only occasionally, seed treatment can be considered good insurance.

But before we buy insurance of any kind, we want to know that the event against which we are insuring ourselves has some chance of occurring. To date I have seen no data from any experiment station showing a case where treated seed produced a good stand and untreated seed an unsatisfactory one. Lack of such data does not, however, prove that such cases may not occur; and if a farmer wants to insure against this possibility, I would advise him to treat his seed.

There is one other case where treatment might be desirable. Because poor quality seed germinates slowly, it is more susceptible than good-quality seed to pre-emergence damping-off, and there is evidence that a fairly good increase in stand may result from treating low-quality seed.

Another point to consider is whether the seed should be inoculated with nodule bacteria. While seed treatment does not kill all the bacteria, tests in sterilized soil have shown that nodules are considerably reduced by such treatment. Ordinary field soil usually already contains many of these bacteria, and therefore this difference cannot be observed. The fact remains, however, that the farmer should make up his mind which will do him the most good, inoculation or seed treatment, and not try to use both.

J. W. Gerdemann
2/9/53

RED CLOVER DISEASES

Root rot of red clover causes more reduction in yields and loss of stands than any other disease. It is present on all red clover plants and is responsible for the eventual death of nearly every plant.

Loss of stands from this cause is, in fact, so universal that it has become accepted as normal. Few persons realize that red clover is a true perennial and that loss of stands during the second summer is not normal. It is only when the disease becomes especially severe and causes high losses before the second cutting that it receives particular attention.

Root rot begins a few weeks after the clover seed germinates, but its progress is usually slow if growing conditions for the clover are good. If unfavorable growing conditions, such as a drouth or a severe winter, occur, the disease spreads more rapidly and the plants die sooner.

Not a great deal is yet known about the nature of root rot, although more information is gradually becoming available. It now appears that it may be a complex group of root diseases. The best hope for control lies in the development of resistant clover varieties. At present one variety, Kenland,is slightly resistant, and it should be used in the southern half of Illinois, where it is well adapted. It might also be used on an experimental basis in northern Illinois, where it is not so well adapted.

Various types of winter injury cause high losses in red clover stands. In addition,winter injury weakens the plants, causing them to become more susceptible to root rot. There are at least three types of winter injury: heaving caused by alternate freezing and thawing, injury from extreme cold, and injury from ice sheets.

Other conditions similar to ice sheets, such as waterlogged frozen soil and heavily packed snow, may also cause winter injury. It has been observed that clover frequently survives winterkilling better on rolling, well-drained soil than on flat, poorly drained soil. The more northern types of clover, such as the Canadian variety Dollard, appear to have some resistance to winterkilling. At present, however, seed of these varieties is available only for experimental use.

Southern anthracnose causes a crown rot of young red clover plants and may also attack and kill stems and leaves. It causes high losses in the southern part of the United States and is present in the southern half of Illinois. The variety Kenland is resistant.

Northern anthracnose kills stems and leaves of red clover in the northern half of Illinois. This disease occurs in the spring during damp, cool weather. It causes reductions in yield and quality of hay but does not kill the plants. When it becomes severe, an entire field may become brown. Usually, however, it is present in only a few fields and does not cause much loss except in unusual years. Most northern varieties have some resistance. The variety Dollard is probably the best, but seed of it is not yet available.

Powdery mildew causes the leaves of red clover to become white and dusty. It is most severe in dry weather but seldom causes much damage. The variety Wisconsin Mildew Resistant is resistant, but its hay yields in Illinois are not high enough to recommend it.

Aphids and leafhoppers transmit viruses that produce mosaic diseases on red clover. The leaves become mottled and streaked with yellow, and the plants are stunted. There are no practical methods of control, but losses from mosaics are relatively low.

There are many other diseases of red clover, such as black stem, black patch rust, and a number of leaf spot diseases. They often cause an important loss in yield and quality of hay. No practical control is known for them.

J. W. Gerdemann
3/2/53

UNIVERSITY OF ILLINOIS · COLLEGE OF AGRICULTURE

AGRONOMY FACTS

F-7

RED CLOVER SEED SUPPLIES AND VARIETY RECOMMENDATIONS FOR ILLINOIS

The supply of red clover seed for Illinois in 1953 will be more than ample. Production of common medium red clover seed for 1952 was above the 10-year (1941-1950) average, and there is a fair supply of certified Kenland. Seed supplies of Midland and Cumberland have become very small and probably will not be increased.

Kenland, a new variety of red clover developed at the Kentucky Experiment Station, is recommended for use in central and southern Illinois. It is not recommended for northern Illinois because it is susceptible to northern anthracnose, a disease of the stems and leaves that lowers hay quality. At present, locally produced red clover seed is recommended for northern Illinois.

Kenland has proved superior in many respects to other strains of red clover in central and southern Illinois. It is resistant to southern anthracnose, a disease whose symptoms are similar to northern anthracnose, but which is caused by an entirely different organism. Besides damaging aboveground, the fungus that causes southern anthracnose frequently invades the root through the crown, causing the plant to die. In addition, Kenland appears to be less susceptible than other varieties to certain other root rots that are causing premature death of plants in practically all red clover fields in Illinois.

Kenland also remains productive longer than other red clover and frequently gives a second cutting when common red clover does not because the stand is severely thinned as a result of root rot.

In trials at Urbana in 1952, the performance of several varieties of red clover was as follows:

Variety	Weeds in hay July 29	Yield of hay June 13	Yield of hay July 29	Yield of hay Seasonal total
	pct.	tons/A.	tons/A.	tons/A.
Kenland	8	1.73	1.30	3.03
Midland	32	1.56	.80	2.36
Medium red (common)	43	1.34	1.05	2.39
Mammoth	97	1.38	....	1.38

J. A. Jackobs
3/2/53

USE AND MANAGEMENT OF GRASS-LEGUME MIXTURE IN PASTURES

Why are grass-legume mixtures recommended for pastures? Usually there are four reasons:

1. Adapted legumes are more productive and give better seasonal distribution of production than grasses.

2. Danger of bloat in grazing animals is greatest on pure legume pasture.[1/]

3. Grass-legume mixtures control erosion more effectively than pure stands of legumes.

4. There is less risk of losing a stand when grasses are included in the mixture. Grasses are also more resistant to low temperatures and heaving and will survive after most legumes are winterkilled.

Legumes are more productive. When all nutrient requirements of plants (except for nitrogen) are met, adapted legumes are more productive than grasses. The reason, in part, is that legumes do not have to depend on the soil for nitrogen, whereas grasses do. Legumes also produce better in the hot summer months than the perennial grasses. Even when large amounts of nitrogen are used on grasses, neither total seasonal production nor summer production approaches that of pure legume stands or grass-legume mixtures.

Mixtures reduce danger of bloat. Most cases of bloat occur while animals are grazing on pure stands of legumes or on mixtures that are predominantly legume. Although the causes of bloat are not well understood, it is known that cattle seldom bloat when grazing on grass. The danger of bloat is not great until over 50 percent of the herbage is legume. For this reason it is desirable to have a mixture that consists of half grass and half legume. The legume will then keep production up, and the grass will reduce the danger of bloat.

Mixtures control erosion. Grasses have a much more fibrous root system than the legumes. Legumes are not so long-lived as the perennial grasses used in pastures; and when pure stands of legumes are winterkilled or otherwise destroyed, the soil surface is exposed to erosion. Grass-legume mixtures will control erosion nearly as effectively as straight grass seedings.

Grasses reduce risk of losing stand. Legumes are not so long-lived as the perennial grasses. In fact, in a grass-legume mixture, the proportion of grass increases and the legume decreases as the stand becomes older. So the proportion of grasses grows as the legumes die out. Grasses are also more resistant to low temperatures and heaving than legumes and will survive after the legumes are winterkilled. In addition, grass protects the legume from heaving. Often when legumes in pure stands heave because of alternate freezing and thawing in the spring, comparable legumes in a mixture with grass remain securely in place.

One of the objectives of pasture management is to maintain equal proportions of grasses and legumes in pasture mixtures. It is difficult, and at times impossible, to attain this objective.

As a stand becomes older, the legume dies out and is replaced by grass. The problem generally is to get enough grass into the mixture the first year after seeding and then to maintain the legume as long as possible as the stand becomes older.

1/ Birdsfoot trefoil is a legume, but no cases of bloat have been reported from its use. Legumes referred to include Ladino clover, alfalfa, red clover, alsike clover, sweet clover, and common white clover.

The best way to accomplish both of these objectives is to seed the right proportion of grass and legume, to seed at a time that will favor the grass, to use or withhold nitrogen fertilizer according to the desired shift, and to follow a grazing management program that will favor the legume after the first year.

Seeding rates. Ladino clover is seldom seeded at a rate of more than 1/2 pound per acre. At a higher rate it may become so dominant in the mixture that the danger of bloat will be great. Alfalfa is seeded at a lighter rate in pasture mixtures than in hay mixtures. Eight to 10 pounds per acre is generally sufficient in a pasture seeding. The amount of grass to seed per acre will depend on the fertility of the soil. For example, on some dairy farms in northern Illinois, 4 to 5 pounds of bromegrass is sufficient in a pasture mixture, but in most cases 6 to 8 pounds should be used.

Time to seed. Late summer and fall seedings favor grass over legume in a mixture. For example, if the same grass-legume mixture is seeded in early spring and in late summer or early fall and the spring seeding has given a mixture that is 90 percent legume, the late summer seeding will be likely to give a mixture that is only 40 to 50 percent legume. Grass seeded in the spring starts to grow slowly and does not compete well with the legume and with weeds during the hot summer. On the other hand, when it is seeded in the late summer or fall, weeds do not offer much competition and the grass continues to grow much later in the fall than the legume.

Location will determine whether fall seedings are feasible. In northern Illinois the growing season is usually not long enough for late summer and fall seedings to become established well enough to survive the winter.

Use of commercial fertilizer. The use of nitrogen fertilizer on a grass-legume mixture will increase the proportion of grass in the mixture and may even eliminate the legume completely if high enough rates are used. Ten to 15 pounds of nitrogen per acre can be used at seeding time to stimulate the grass. Sometimes the legume is also stimulated, but not to the same extent as the grass.

It is usually not practical to apply nitrogen to increase the proportion of grass in a mixture after it has become established because there will be little increase in yield and, in fact, yield may even be reduced because of the reduction of the legume in the stand. As the stand becomes older, however, and productivity declines because of disappearance of the legume, it may be desirable to use up to 40 pounds of nitrogen per acre the last year before the stand is plowed out and reestablished.

Legumes can be maintained longer if liberal top-dressings of phosphorus and potash carriers are used when the soil is low in available forms of these elements. This is particularly true of potash in southern Illinois, where applied potash is converted to an unavailable form in a year or two--long before the stand should be plowed out. Two hundred to 250 pounds of an 0-20-20 fertilizer top-dressed every other year will meet the requirements of legumes in most pastures.

Grazing management. Time and intensity of grazing affect the legume in a mixture more than the grass. Response of prostrate legumes like Ladino clover to grazing management is quite different from that of erect-growing legumes like alfalfa. Frequent close grazing is harmful to most species of grasses and legumes, but moderately frequent and moderately close grazing will favor Ladino clover over grass. Such management is, however, harmful to alfalfa. If a mixture that includes Ladino is left to grow until the hay stage, the Ladino will decline in the mixture. If a mixture that includes alfalfa is left to grow until the hay stage, the alfalfa will become more prominent.

J. A. Jackobs
1-18-54

UNIVERSITY OF ILLINOIS · COLLEGE OF AGRICULTURE

AGRONOMY FACTS

F-9

TALL FESCUE VS. SMOOTH BROMEGRASS

Which grass is better for pasture: tall fescue or smooth brome? The answer depends on where the pasture is located in the state and what kind of livestock is to be pastured.

For summer grazing, smooth brome is superior to tall fescue. It is as productive as tall fescue and is much more palatable.

For winter, spring, and late fall grazing, tall fescue is superior to smooth brome. It begins to grow earlier in the spring than the brome, and it stays green and palatable longer into the fall and winter. While tall fescue is not a true sod-forming grass, it holds animals up remarkably well on wet soils. For this reason it is particularly well adapted to winter and spring grazing.

The soil requirements are not so exacting for tall fescue as for smooth brome. Smooth brome requires a well-drained soil that is high in mineral nutrients as well as nitrogen if a productive stand is to be maintained. Tall fescue, on the other hand, will grow well on poorly drained, acid soils that are only moderately high in mineral nutrients. Smooth brome has never flourished on the light-colored soils in the southern third of Illinois. Tall fescue has produced very well on these soils after recommended amounts of lime and fertilizer have been applied.

The question, then--which is better for pasture: tall fescue or smooth brome?--can be answered as follows:

1. If smooth brome can be grown, and if winter grazing is not feasible because of low temperatures, then smooth brome should be seeded instead of tall fescue.

2. If smooth brome does not thrive, then tall fescue is the best grass to use.

3. If smooth brome can be grown and mild winters allow winter grazing, then brome-legume pastures should be established for summer grazing and tall fescue—legume pastures for winter grazing.

In general it can be said that smooth brome is better than tall fescue on the dark-colored soils in the northern two-thirds of Illinois. The brome does very well on these soils, and winter grazing is not commonly practiced here because of low temperatures.

On the light-colored soils in south-central and southeastern Illinois, however, where smooth brome does not thrive, tall fescue appears to be the best pasture grass to use. In southwestern Illinois, where smooth brome does very well on many soils, both it and tall fescue should be used in pasture programs, because winter grazing is practiced throughout southern Illinois.

Beef cattle graze tall fescue much better than do dairy cattle or sheep. If tall fescue pasture is to be used for either dairy animals or sheep, better than average grazing management will be needed.

J. A. Jackobs
10-19-53

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AGRONOMY FACTS

LADINO CLOVER[1/]

Ladino clover is a giant form of white clover that yields about twice as much dry matter as other white clover types. It makes nutritious forage for all classes of livestock and is well adapted in Illinois, growing best on fertile, moist soils.

Although Ladino is used principally for forage, if handled carefully it makes good-quality hay and grass silage. It needs to be carefully managed to keep the stand productive and also to make it safe for cattle and sheep to graze. Normally it should be grown in mixtures with other grasses and legumes.

Danger from bloat. Along with lush alfalfa and other succulent legumes, Ladino clover has been blamed for numerous cases of bloat in livestock. Range cattle that have been fed on short prairie grasses are particularly subject to bloating. Agronomists and veterinarians suggest the following steps to help cut down chances of bloat:

1. Seed only 1/2 pound of Ladino clover an acre with a well-adapted grass or legume-grass mixture.

2. Apply adequate fertilizers and follow proper grazing management in order to maintain a good proportion of grasses in the stand.

3. Let animals graze for only a few hours the first two or three days.

4. Don't turn cattle or sheep onto wet pasture.

5. Feed hay or other roughage before and during pasturing.

6. Be especially careful to full-feed range cattle before pasturing them.

7. Keep a close watch for bloating animals so that they can be removed or treated immediately.

Maintaining a stand. Ladino clover does not persist without careful management. Winterkilling, drought, heat, overgrazing, and other hazards make reseeding necessary during the year. Rotational grazing will allow one plot to reseed itself while others are being pastured.

Pastures may be purposely undergrazed early in the season when growth is rapid. Deferred grazing not only permits natural reseeding, but also provides a growth of highly nutritious forage that will be ready later when growth is slower.

Distinguishing Ladino from white clover. Because Ladino yields better than white clover, a pasture mixture containing only Ladino and not a mixture of white clover types is desirable. It is hard to tell Ladino and white clover apart because they are similar in shape, color, and markings of leaves and flower heads and in shape, color, and size of seeds. However, under similar favorable conditions Ladino will be two to four times the size and height of common white clover and will usually have fewer flower stalks. Because size can be affected greatly by environment, there is no sure way to distinguish between the two types by their vegetative characteristics.

1/ Refer to Circular 650, Ladino Clover in Illinois, for general cultural practices.

Vascular bundle number varies. Several investigators have conducted studies of the number of vascular bundles in the petioles. Although this method offers possibilities of distinguishing the larger Ladino plants from the medium-sized white clover plants, it does not help materially in identifying plants of similar size of the two types (e.g., Ladino growing under poor soil conditions and white clover under very favorable conditions). There is a definite correlation between diameter of petiole and vascular bundle number, and therefore equal-sized petioles of Ladino and white clover generally have the same number of vascular bundles per petiole.

Certification of seed. Variations in the genetic make-up of different certified Ladino clover seedlots can be observed by studying the cyanogenic properties of the white clovers. Cyanogenic property is the ability of a plant to release hydrocyanic acid gas (prussic acid) when mascerated or cut. No cases of hydrocyanic acid poisoning have been reported for Ladino clover as has occurred when immature Sudan grass is pastured.

Original Ladino clover from Italy has appeared to be almost free from cyanogenic properties. The frequency of plants having cyanogenic properties from U. S. seedlots has been shown to vary from 0 to 87 percent. This variation may be due to (1) a difference in the original seedlots imported from Italy, (2) shifts occurring as a result of natural selection, and (3) outcrossing with other white clover types.

Whatever the reason, there have been changes in genetic make-up that point to the need for improving the method of certifying Ladino clover seed. The difficulty of identifying plants and seeds is the major problem in field and laboratory inspections. No observable lowering of production has been noted because of this genetic shift in certified Ladino clover, and through certification it is hoped to keep Ladino clover a high-producing, nutritious forage crop.

H. L. Portz
10-26-53

COMMON ALFALFA DISEASES

Bacterial wilt may cause losses of stands of susceptible alfalfa varieties. Diseased plants are stunted and produce many fine stems, giving the plants a bushy appearance. Leaves are small and light green or yellow. A sure sign of wilt infection is the yellow-brown color in the woody tissue of the root just under the bark. Infected plants eventually wilt and die.

Two wilt-resistant varieties, Buffalo and Ranger, are available. Buffalo is adapted to southern and central Illinois, and Ranger is best for the north.

Wilt seldom causes damage during the first two years of the life of a stand. Therefore, if a stand is desired for only two years, it may be desirable to seed a wilt-susceptible type, since seed of resistant varieties costs slightly more.

Common leaf spot may be recognized by the small circular brown spots on the leaves. If the spots become numerous, the leaves turn yellow and fall. In the center of each spot is a small raised disk, the fruiting body of the fungus which causes the disease. When infected leaves fall to the ground, the fruiting body shoots its spores up into the leaves and causes new infection.

If possible, heavily infected stands should be cut before the leaves fall. Then the quality of the hay will be maintained and much of the fungus will be removed from the field, giving the new crop a better chance to remain healthy.

This disease appears to be worst on acid or low-fertility soils. On good soils the plants are better able to "outgrow" the disease. Seedling stands often become heavily infected with leaf spot but, although the plants may be severely stunted the first year, it does not seem to cause any permanent damage.

Plant breeders are attempting to develop leaf-spot-resistant varieties.

There are other leaf spot diseases of alfalfa--leaf blotch, Stemphylium leaf spot, and rust--that sometimes cause damage. The control measures recommended for common leaf spot also apply to them.

Black stem causes a blackening of the lower stems and may stunt the plants and kill young shoots. It is most common in cool, wet weather. There are no satisfactory control measures.

Downy mildew seldom damages alfalfa stands, but it often causes some concern because of its striking symptoms. This disease appears on the new growth in cool, wet weather. Leaves become light yellow, especially at the tip of the stem, and a grayish-white moldy growth can be found on the underside of infected leaves. Control measures are usually unnecessary.

Boron deficiency causes alfalfa plants to become stunted. The leaves are yellow to purplish in color. The terminal buds may die and the lateral branches grow, causing the stems to appear "broomed." Internodes of the stem are much shortened. Alfalfa is very sensitive to boron deficiency. Because it is easily confused with leafhopper damage, it is best to test the soil for boron if there is any doubt.

J. W. Gerdemann
4-12-54

OAT VARIETIES FOR ILLINOIS

Many varieties of oats are adapted to Illinois, but only a relatively few are commonly used. The list below does not include all of the varieties that are adapted to the particular section indicated, but it does give those that are most popular:

Northern:	Clinton, Bonda, Nemaha, Missouri 0-205, LaSalle
Central:	Clinton, Bonda, Nemaha, LaSalle, Missouri 0-205, Marion, Columbia
Southern:	Benton, Missouri 0-205, Nemaha, Columbia, LaSalle

The most popular variety in the southern part of the state has been Clinton because of its ability to stand until harvest. However, experiments at Brownstown and Dixon Springs show that LaSalle, Missouri 0-205, Benton, and Nemaha should be recommended over Clinton in this section because of their higher yields.

Recommended Varieties

LaSalle was developed at Illinois by O. T. Bonnett from the cross Clinton x Marion. Seed will be distributed to experienced growers of certified seed in the spring of 1953. A yellow-kerneled variety, LaSalle matures three or four days earlier than Clinton, grows to about the same height, and is less resistant to lodging, although it is superior in this respect to Marion and Andrew. LaSalle has not equaled Clinton in yield at the DeKalb field but has been superior to it at both Urbana and Brownstown. It is intermediate in response to septoria and susceptible to race 7 of stem rust, but somewhat tolerant to 45 and similar races of leaf rust. Although it does not equal Clinton in test weight, it is satisfactory in this respect.

Clintafe, a new variety, was developed by Iowa from the cross Clinton x Santa Fe. Santa Fe, introduced from Argentina, is late, susceptible to lodging, and not adapted to the Corn Belt. It does, however, have good resistance to 45 and similar races of leaf rust and to septoria black stem disease. Clintafe is the result of a breeding program having two aims: first, to obtain the disease resistance of Santa Fe by crossing this variety with Clinton and, second, to regain as many as possible of the desirable qualities of Clinton through a series of back-crosses to Clinton.

Clintafe matures two or three days later than Clinton, grows about two inches taller, and appears to equal it in yield in northern Illinois. It is, however, lower in test weight and not quite so resistant to lodging, although possibly better in this respect than Missouri 0-205 or LaSalle. Clintafe, when available, will be resistant to race 45 and approach Clinton in lodging resistance. It will be adapted to northern Illinois. Seed will not be available until after the 1953 harvest.

Benton, selected by Indiana from the cross D-69 x Bond, is similar to Clinton except that it ripens a day or two earlier in southern Illinois and grows six to eight inches taller. It also has a higher yield record than Clinton in this area. Benton is tolerant to septoria and shows some tolerance to race 45 but is susceptible to race 7 of stem rust.

Bonda, selected by Minnesota from the cross Bond x Anthony, has a white kernel, grows about four inches taller than Clinton, matures at about the same time, and has the same resistance to the rusts and septoria. It has the highest test weight of any oat recommended for Illinois, consistently running two or more

pounds heavier than Clinton and other varieties. Bonda yields well in northern and central Illinois but is not recommended for southern Illinois.

Andrew, developed by Minnesota from the cross Bond x Rainbow, has a yellow grain and the same resistance to disease as Clinton except that it is susceptible to races 8 and 10 of stem rust rather than race 7. It may have some tolerance to 45 and similar races of leaf rust but is susceptible to septoria. Andrew is not so resistant to lodging as Clinton, and its maturity date varies; in some years it will mature at the same time as Clinton and in others will be somewhat earlier. It has a good yield record in both northern and central Illinois.

Nemaha, developed by Iowa from the double cross Victoria-Richland x Morota-Bond, was released by Kansas and Nebraska in 1948. It has a reddish-yellow kernel color, grows about three inches shorter than Clinton, and matures two or three days earlier. It is not so resistant to lodging as Clinton but is slightly better than Andrew. Nemaha has a good test weight and a slightly lower yield than Clinton in northern and central Illinois, although it has outyielded Clinton in southern Illinois. It is intermediate in resistance to septoria, tolerant to 45 and similar races of leaf rust, and susceptible to race 7 of stem rust.

Marion, from Markton x Rainbow, was released by Iowa in 1939. It has white kernels, is resistant to stem rust except races 8 and 10, has some tolerance to race 45 of leaf rust, and is susceptible to septoria and lodging. Marion has an excellent yield record in northern and central Illinois but does not yield well in southern Illinois. It matures slightly earlier than Clinton.

Columbia, selected by Missouri from Fulghum, matures about five days earlier than Clinton. It is very susceptible to smut and rust except race 45 and similar races of leaf rust, and is resistant to septoria. In spite of these disadvantages, it has never gone completely out of the picture in Illinois, primarily because of its earliness and relatively good yield record.

Missouri 0-205, selected by Missouri from the cross Columbia x Victoria-Richland, is similar to Columbia in plant and seed characteristics and about two days later than Columbia but two to three days earlier than Clinton. It grows three or four inches taller than Clinton. Missouri 0-205 is comparable to Nemaha in resistance to lodging. It is resistant to race 45 of leaf rust and race 7 of stem rust, susceptible to races 8 and 10 of stem rust, and tolerant to septoria. It has a good test weight.

Clinton and derivatives, such as Clinton 11 and 59, are from a cross of D69 x Bond. Clinton, released in 1946, is susceptible to 45 and similar races of leaf rust and to race 7 of stem rust. It is outstanding in lodging resistance, has good test weight and yield, and matures about five days later than Columbia.

Varieties Not Recommended

Abegweit.....late; low test weight
Advance......late
Ajax.........susceptible to rust
Beaver.......late; low test weight
Bonham.......low yield
Branch.......late
Cherokee.....low yield
Colo.........late; low yield
Craig........late
Eaton........low yield
Exeter.......late; susceptible to rust
Fortune......late; susceptible to rust; low test weight
James Hulless Bond.....low yield
Lorain.......susceptible to rust; low yield
Mo. 0-200....low yield; susceptible to lodging
Shelby.......late
Zephyr.......late; light test weight

W. O. Scott
1/12/53

AGRONOMY FACTS

G-1 Revised

1954 OAT VARIETIES FOR ILLINOIS

Although many varieties of oats are adapted to Illinois, only a relatively few are commonly used. The list below does not include all varieties that are adapted to the particular section, but it does give those that are new and most popular in each section.

Northern

High fertility:	Clintland,* Clinton, Clintafe, Bonda
Medium to low fertility:	Same as above plus Branch, Mo. 0-205 LaSalle, Nemaha

Central

High fertility:	Clintland,* Clinton, Bonda, Benton
Medium to low fertility:	Mo. 0-205, LaSalle, Andrew, Nemaha

Southern

	Mo. 0-205, Nemaha, LaSalle, Benton

Oat yields in 1953 were generally disappointing. Disease and extremely high temperatures at "filling" time reduced yields and quality. Race 7 of stem rust damaged susceptible varieties in some sections. Where damage occurred, farmers may be discouraged with Clinton and want a stem-rust-resistant variety.

At present all resistant varieties are much more susceptible to lodging than Clinton. It is therefore necessary to choose between disease resistance and stiff straw. Bad stem-rust years could conceivably follow consecutively. It is possible that 1954 will be another rust year. But the records show that severe damage can be expected only once every 5 to 10 years. Therefore on highly fertile soils rust may be a lesser gamble than lodging.

*Not available commercially until 1955.

Recommended Varieties

Clintland* was developed at the Indiana Station from the cross Clinton x Landhafer after it had been backcrossed to Clinton 3 times. Seed of this new variety will be increased in Illinois and distributed in 1955. Clintland is similar to Clinton in maturity, plant appearance, lodging resistance, and grain characteristics. It is resistant to Race 45 and all other crown rust races now found in the Corn Belt. It is susceptible to Race 7 and resistant to Race 8 of stem rust and moderately resistant to Septoria black stem. When seed is available, it is expected to replace a large part of the acreage now devoted to Clinton.

Clintafe was developed by the Iowa Station from the cross Clinton x Santa Fe backcrossed to Clinton 2 times. Seed is available in Illinois for 1954 planting. Clintafe matures 2 to 3 days later than Clinton, grows about 2 inches taller, and is about comparable in lodging resistance. But it is slightly lower in test weight. Clintafe is resistant to Race 45 and susceptible to Race 7 of stem rust. It is highly resistant to Septoria black stem. Because it matures rather late, we recommend it primarily for the northern part of Illinois.

Branch was developed at the Wisconsin Station from Forward x (Victoria-Richland) backcrossed to Forward. Branch matures 5 to 7 days later than Clinton, grows 4 to 5 inches taller, is about comparable to Mo. 0-205 in lodging resistance, and is moderately resistant to Race 45 of crown rust. It is also resistant to Race 7 but susceptible to Race 8 of stem rust. It is one of the most resistant varieties to Septoria black stem. Because it matures late, it should be confined to the northern part of the state.

LaSalle was developed at the Illinois Station from the cross Clinton x Marion. It was distributed to certified seed producers in 1953. It is a yellow kerneled variety that matures 3 or 4 days earlier than Clinton, grows to about the same height, and is less resistant to lodging, although it is superior in this respect to Marion and Andrew. LaSalle has not equaled Clinton in yield at the DeKalb field but has been superior to it at both Urbana and Brownstown. It is susceptible to Race 7 of stem rust but is somewhat tolerant to Septoria and Race 45 and similar races of leaf rust. Although it does not equal Clinton in test weight, it is satisfactory in this respect.

Clinton and derivatives, such as Clinton 11 and 59, are from a cross of D69 x Bond. Clinton, released in 1946, is susceptible to 45 and similar races of leaf rust and to Race 7 of stem rust. It is outstanding in lodging resistance, has good test weight and yield, and matures about 5 days later than Columbia.

Benton, selected by Indiana from the cross D69 x Bond, is similar to Clinton except that it ripens a day or two earlier in southern Illinois and grows 6 to 8 inches taller. It also has a higher yield record than Clinton in this area. Benton is tolerant to Septoria and shows some tolerance to Race 45 but is susceptible to Race 7 of stem rust.

Bonda, selected by Minnesota from the cross Bond x Anthony, has a white kernel, grows about 4 inches taller than Clinton, matures at about the same time, and has the same resistance to the rusts and Septoria. It has the highest test weight of any oat recommended for Illinois, consistently running 2 or more pounds heavier than Clinton and other varieties. Bonda yields well in northern and central Illinois but is not recommended for southern Illinois.

Andrew, developed by Minnesota from the cross Bond x Rainbow, has a yellow grain and the same resistance to disease as Clinton except that it is resistant to Race 7 of stem rust and susceptible to Race 8. It may have some tolerance to 45 and similar races of leaf rust but it is susceptible to Septoria. Andrew is not so resistant to lodging as Clinton, and its maturity date varies; in some years it matures at the same time and in others it is somewhat earlier. It has a good yield record in both northern and central Illinois.

Nemaha, developed by Iowa from the double cross Victoria-Richland x Morota-Bond, was released by Kansas and Nebraska in 1948. It has a reddish-yellow kernel color, grows about 3 inches shorter than Clinton, and matures 2 or 3 days earlier. It is not so resistant to lodging as Clinton but is slightly better than Andrew. Nemaha has a good test weight and a slightly lower yield than Clinton in northern Illinois. It is intermediate in resistance to Septoria black stem, tolerant to 45 and similar races of leaf rust, and susceptible to Race 7 of stem rust.

Mo. 0-205, selected by Missouri from the cross Columbia x Victoria-Richland, is similar to Columbia in plant and seed characteristics and about 2 days later than Columbia but 2 or 3 days earlier than Clinton. It grows 3 to 4 inches taller than Clinton. Mo. 0-205 is comparable to Nemaha in resistance to lodging. It is resistant to Race 45 of leaf rust and Race 7 of stem rust, susceptible to Races 8 and 10 of stem rust, and tolerant to Septoria black stem. It has good test weight.

Varieties Not Recommended

Abegweit - late; low test weight
Advance - late
Ajax - susceptible to rust
Beaver - late; low test weight
Bonham - low yield
Cherokee - low yield
Colo - late; low yield
Craig - late
Eaton - low yield
Exeter - late; susceptible to rust
Fortune - late; susceptible to rust; low test weight
James Hull-less Bond - low yield
Larain - susceptible to rust; low yield
Mo. 0-200 - low yield, susceptible to lodging
Shelby - late
Zephyr - late; light test weight

The following varieties are not recommended because their adaptability to Illinois conditions has not been determined: Rodney, Lanark, Sauk, Valor.

W. O. Scott
12-14-53

CROWN RUST OF OATS (*Puccinia coronata avenae*)

Economic importance. Crown rust, or leaf rust, as it is often called, appears almost everywhere oats are produced. The amount of infection depends on the amount of inoculum (spores) present in the early spring, the acreage of susceptible varieties, and weather conducive to optimum growth and development of the fungus.

In Illinois the annual loss from crown rust in the past 10 years, as estimated by Mr. G. H. Boewe, Natural History Survey, has ranged from 2 to 15 percent. Race 45 and similar races have been largely responsible.

Symptoms. Crown rust occurs principally on leaves of the oat plant, although it is often present, especially in susceptible varieties, on the leaf sheath, stems, and panicles. There are two stages of the disease: the orange-yellow or summer stage and the black or winter stage.

The rust spots (pustules) of the summer stage are usually more or less circular, although some of them are much longer than they are wide. The number and size of the pustules vary greatly, depending on the susceptibility of the variety and the severity of the infection. The pustules of the summer stage rupture the epidermis.

Later in the season the black or winter stage appears. This stage does not rupture the epidermis as does the summer stage of black stem rust.

The other (alternate) host for crown rust is any one of a number of species of buckthorn (Rhamnus). On this host bright yellow or orange spots first appear on the upper surface of the leaf. Opposite these spots, usually on the undersurface of the leaf, the cluster-cup stage appears. This stage is similar in appearance to that of stem rust on barberries.

Life cycle. The life cycle of the crown rust fungus is similar to that of stem rust except that the cluster-cup stage develops on buckthorn instead of on barberries. In Illinois the summer stage seldom, if ever, winters over. Early spring infection develops from the cluster-cup stage on buckthorn. Also, summer spores may be blown in from the southern states where they live through the winter on fall-seeded oats.

Physiologic races. Over 100 distinct races of crown rust have been discovered. They differ only in their ability to attack certain varieties of oats. For example, Race 45 attacks the Bond-type oats, such as Clinton and similar varieties, but not Vicland.

Race 45 was first discovered about 1937, but was of little consequence at that time. However, since the introduction of the Bond-type oats, Race 45 and similar races have become increasingly widespread and of great economic importance. At present these races constitute about 90 percent of the rust occurring on oats over the entire United States.

Like barberry for stem rust, buckthorn serves as a source of development of new races of crown rust. The sexual stage occurs on buckthorn, and this plant is the common host for all the races. Consequently, if two races infect the buckthorn at the same time, it is possible for them to cross or hybridize and produce a new race or races.

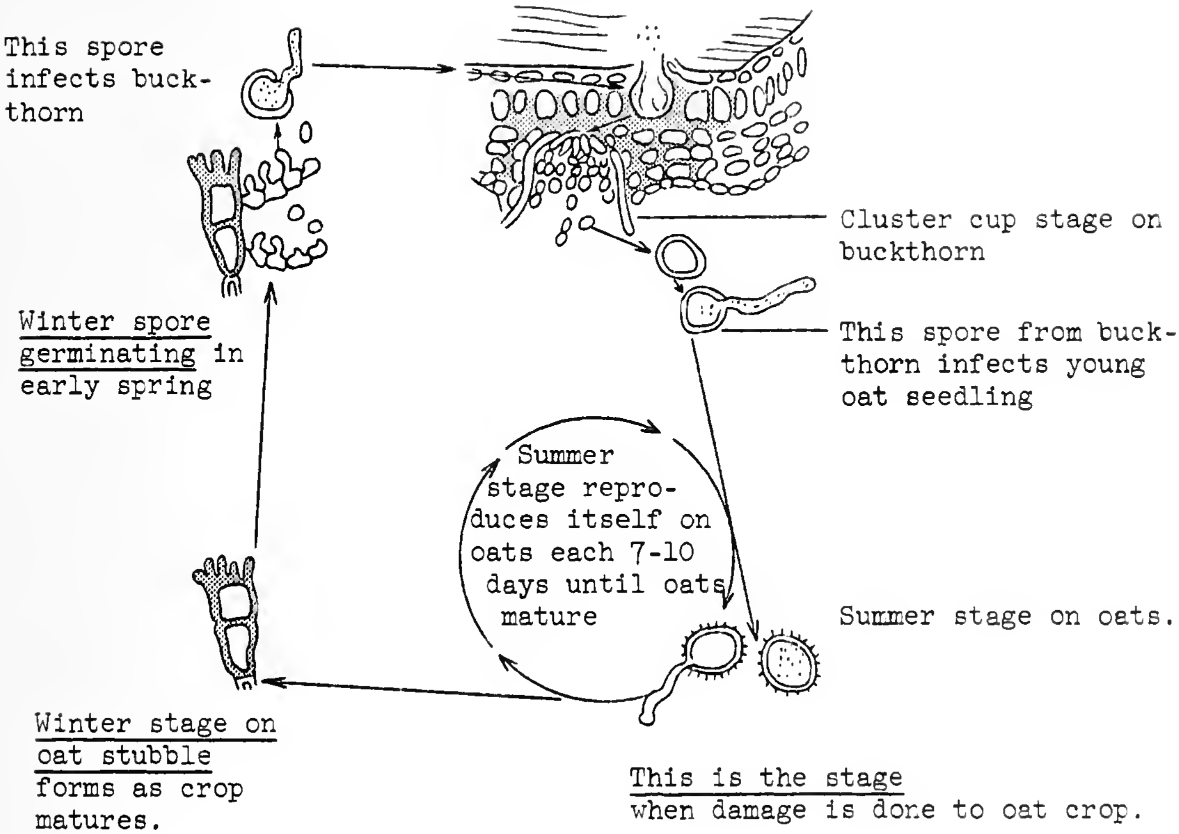
Control. Some states recommend eradication of buckthorn to reduce the source of new races of rust. At present, the only practical means of control, however is the use of resistant varieties.

A few new varieties are being introduced that are highly resistant to all the present crown rust races; and until new races appear, these varieties will materially reduce the loss due to crown rust.

Considerable work is being done in testing different antibiotics and fungicides for use in controlling rust. These tests are not being carried out with the idea of spraying or dusting the entire oat acreage, but for the purpose of controlling a local outbreak and preventing the development of a general epidemic.

W. M. Bever
1/12/53

DIAGRAMMATIC SKETCH OF LIFE
CYCLE OF CROWN RUST



GREY SPOT OF OATS

"Grey spot," first observed in local areas in 1948, was general throughout the state in 1949. Since that time it has occurred each year but has not been nearly so extensive as it was in 1949. The cause is not yet known.

This disease is best observed at the time the oats are turning from green to yellow, a few weeks before they are ready to harvest. The plants in the infested part of the field are ashy gray and a little shorter than the healthy plants. It is practically impossible to recognize the disease before this stage of growth.

A reddening and premature dying of the leaves may occur when the plants are 1 to 2 feet high, but this is not always true. The infested area is usually circular and from 4 to 20 feet in diameter. Sometimes the infested areas overlap, creating a much larger area. All plants within an infested spot are ashy gray in color. None of them escape. Grey spot has no apparent effect on seed germination, however.

Experimental tests have shown that yield is reduced as much as 10 bushels per acre and test weight is lowered as much as 4.5 pounds per bushel within the diseased spots. The seed is always light and chaffy.

Until a technic has been developed for producing grey spot artificially, varietal resistance on susceptibility cannot be studied in detail. Field observations indicate, however, that all varieties in commercial production in Illinois are susceptible. Crop rotation has no effect on the incidence of the disease.

W. M. Bever

BLACK STEM DISEASE OF OATS (Septoria avenae)

Black stem disease of oats was first reported in the United States in 1922. Until recently, however, it was not considered important, and relatively little research work was done on it. Only in the past few years has it become economically important, and even now no figures are available on the damage it causes in Illinois.

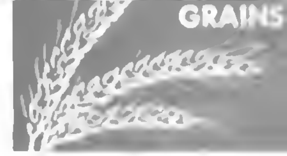
Symptoms. The first noticeable symptoms appear in the early spring as small purplish brown spots on the leaves. As the spots grow, the infected leaf tissue dies. In severe cases the spots may combine, causing the leaf to die prematurely.

Sometime after heading the black stem symptom begins to appear. It is usually observed first on the leaf sheath and around the point where the leaf is attached to the sheath. From there it spreads to the stem of the plant. Because of the stem lesions, susceptible varieties will lodge considerably at the points of infection.

When conditions are optimum for growth of the black stem fungus, considerable browning of the hulls will also occur. This brown discoloration has no noticeable effect on germination of the seed, however.

Control. Not too much is known at present about the life cycle and overwintering habits of the black stem fungus. At present no oat variety appears to be entirely immune, although some varieties, such as Andrew, Marion, and Colo, seem more susceptible than others.

W. M. Bever
1/12/53



ROW SPACING FOR SMALL GRAINS

What about widening small grain rows to increase legume-grass stands? This question is not new but is coming more often as a result of recent articles in farm papers.

Whenever two or more crops are seeded on the same piece of ground, they must compete for moisture, nutrients, and light. For instance, when clover is seeded in small grain, the grain is, by nature, far the more aggressive competitor. Its rapid top growth often shades the legume before its first true leaf is out, while its extensive, fibrous root system rapidly depletes the soil of moisture.

Wider spacing of small grain rows is a simple cultural method of reducing competition. As in many other cultural operations, however, the benefits to be gained will depend on the growing season. A deficiency of soil moisture has been found to be by far the most important single factor in retarding plant growth. The period when the moisture is deficient is also important.

The need of clover stands on highly fertile soil at Urbana for moisture during May and June is shown in the following table:

Table 1.--Effect of Rainfall During May and June on Clover Stands at Urbana, Illinois, 1948-52

Year	Rainfall	Stand 8"rows	Stand 16"rows
		perct.	perct.
1948	Below normal	15	50
1949	Normal	100	100
1950	Below normal	30	60
1951	Above normal	100	100
1952	Normal	90	100

In two of the five years stands were significantly better in the wide rows. During seasons with normal or above-normal rainfall individual legume seedlings were not so vigorous in narrow rows as in wide rows, but this difference generally disappeared after small-grain harvest.

Several disadvantages of wide row spacing might be pointed out:

First, it is necessary to use a grain drill rather than broadcast. Many Illinois spring oat growers do not have grain drills.

Second, grain yields are generally reduced from 10 to 20 percent when rows are widened from 8 to 16 inches (see Table 2 on page 2).

The most promising row spacing for obtaining good clover stands with the least sacrifice in grain yield appears to result from plugging every third drill hole rather than every other hole.

Three basic problems have been encountered in widening winter wheat rows: (1) erosion is increased, (2) winterkilling is increased, (3) spring seeding conditions and certain soil types found particularly in southern Illinois sometimes favor establishment of the clover in the grain row rather than between the row. Under these conditions widening the rows actually causes a decrease in clover stand and an increase in weed population.

Should the same amount of seed be used per acre in wide rows as in regular spacing? In wheat, seeding at the same rate seems desirable because the heavier seeding increases winter survival. In spring oats, little or no yield increase

has been obtained from seeding heavy amounts per row; therefore the acre rate can be decreased when rows are widened.

Another interesting result of the row spacing trials is the consistently higher test weight of grain obtained from closely spaced rows than from wide rows. The difference is generally small, although in certain tests it has approached 2 pounds

Summary. Wide grain rows reduce the competition between grain and clover for moisture, nutrients, and light. However, the primary factor appears to be the availability of soil moisture during May and June. In seasons when dry periods occur during either of these two months, wide grain rows may make the difference between success and failure of the clover stand. However, grain yields from wide rows are about 10 to 20 percent lower than yields from regular 8-inch rows. The most promising spacing arrangement appears to be plugging every third drill hole rather than every other hold.

Table 2.--Yields of Spring Oats and Winter Wheat From Various Row Spacings at Urbana, Illinois, 1950-52

Row spacing	Spring oats				Winter wheat		
	1950	1951	1952	Average	1951	1952	Average
	bu.	bu.	bu.	bu.	bu.	bu.	bu.
8-inch rows	77.7	46.5	79.6	67.9	39.4	36.2	37.8
16-inch rows	63.6	37.9	68.3	56.6	28.2	35.0	31.6
24-inch rows	50.9	25.1	54.7	43.6	20.4	34.0	27.2
Two 8-inch rows with 16-inch space	68.1	43.4	72.9	61.5	33.8	39.1	36.5
Two 4-inch rows with 16-inch space	69.8	40.1	74.6	61.5	35.4	40.0	37.7
Broadcast	67.5	47.7	69.7	61.6	....	....	....

J. W. Pendleton
1/12/53

AGRONOMY FACTS

SOW SPRING GRAINS EARLY

Spring small grains should be seeded as soon as the soil is in condition to work. Early sowing is particularly essential for success with spring wheat, especially if this crop is being attempted in north-central and central Illinois. It is not advisable to sow spring wheat at all in the southern part of the state. The data on seeding dates for spring wheat shown in the table below were obtained at Urbana.

Early seeding makes for deep rooting of plants and advances the maturity of the crop. In late-seeded crops the partially mature plants are often exposed to unfavorably high temperatures and to environments that are conducive to infection by scab and rust diseases.

Although spring barley is not so sensitive to late seeding as is spring wheat, early sowing is very necessary for good results. In central Illinois, oats should be seeded between the middle of February and the middle of March.

Spring oats do well in northern Illinois when seeded any time during the last half of March and April 20; but in the central and southern parts of the state April seeding distinctly reduces yield. Oats seeded in May are so poor that, if it were not for their service as a companion crop for legume and grass, they would be considered a failure. The graph on the back of this page shows yield trend curves taken from many years of experience in seeding oats in central and southern Illinois.

Yield drops off more sharply with late seeding in southern than in central Illinois, and it drops off very rapidly as a result of May seeding. From the first half of March to the last half of April--46 days--the yield fell from 100 to 64 percent. This is a rate of about 3/4 percent for each day seeding was delayed. After the last half of April, yield dropped 1 1/2 percent for each day seeding was postponed.

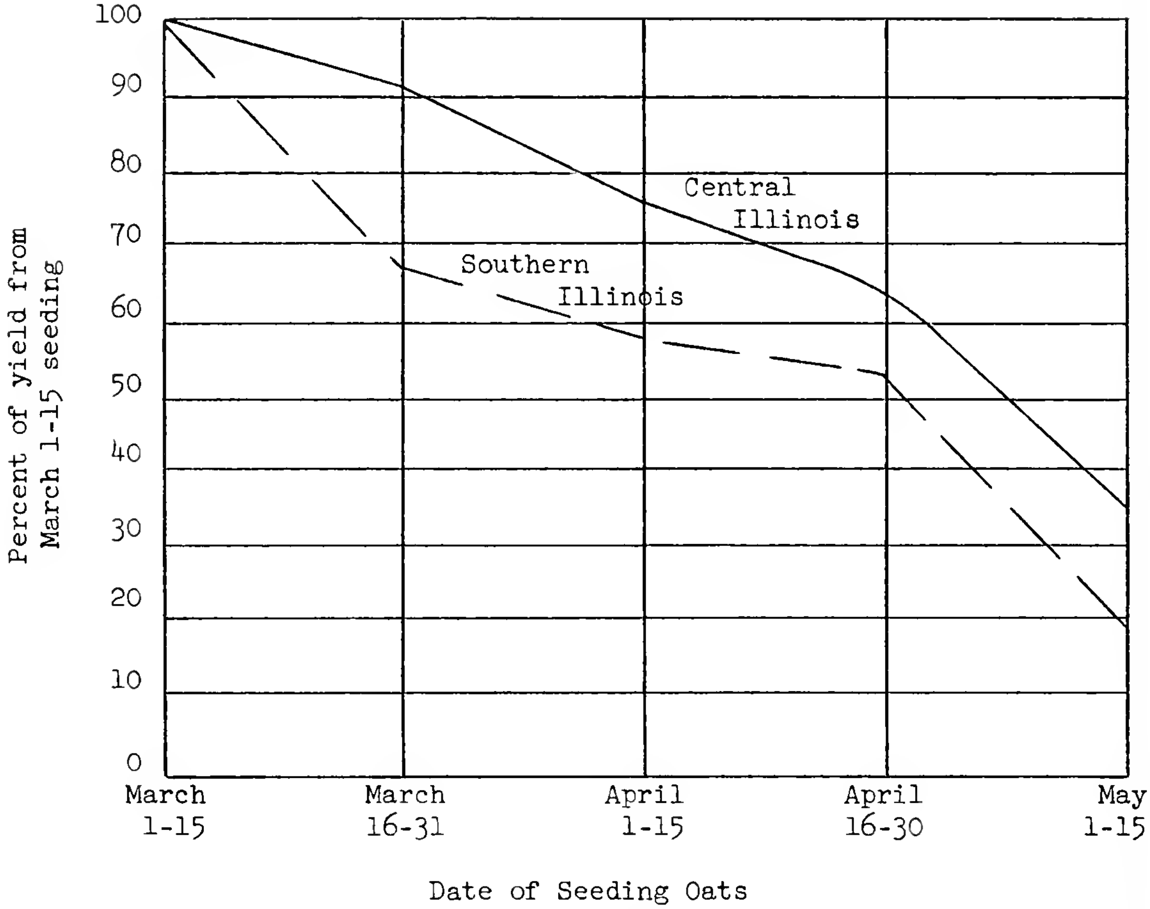
In southern Illinois, yield fell off about 1 percent per day of delay in seeding up to the last half of April, and after that time the drop in yield was about 1 3/4 percent for each day seeding was delayed.

These statements apply to an average of seasons. Exceptionally cool seasons will permit oats seeded in May to yield more than these figures indicate. It is not harmful even in such seasons to seed oats early. They will always perform well. Hard freezes have been known to kill some of the plants, but the remaining ones will yield more than later seeded oats. Therefore, do not be afraid of seeding oats too early.

G. H. Dungan
2/2/53

Date of seeding wheat	Yield per acre	Weight per bushel	Heads infected with scab
	bu.	lb.	perct.
March 6	29.3	59.9	1.5
March 16	25.4	58.7	3.4
March 29	22.8	57.7	6.5
April 10	22.2 1/	54.8 1/	14.8 1/

1/ Data for Marquis variety. Other data are averages of both Marquis and Illinois 1.


Percent of yield from
March 1-15 seeding
100
90
80
70
60
50
40
30
20
10
0
Central
Illinois
Southern
Illinois
March
1-15
March
16-31
April
1-15
April
16-30
May
1-15
Date of Seeding Oats

NITROGEN FOR ILLINOIS WHEAT

Most of the wheat grown in Illinois is winter wheat. It has a moderate (but rather exact) requirement for nitrogen. Wheat grown on soil that contains too much nitrogen tends to produce an excessive amount of straw. It also lodges and the quality of the grain is poor. Wheat grown on nitrogen-deficient soil is stunted, ripens prematurely, and produces low yields.

In Illinois, winter wheat is usually grown in rotation with corn, soybeans, other small grains, and legumes. The legumes serve as the main source of nitrogen for the other crops. Because the wheat is an excellent nurse crop for legume seedings, it usually precedes the legume and thus occupies a place in the rotation where the legume-supplied nitrogen is low. During recent years, however, a fairly large part of the wheat in Illinois has been seeded after soybeans that have followed at least one corn crop.

Whether or not wheat will respond to nitrogen fertilizer depends mainly on how far in advance of the wheat crop the legume was grown and how successful it was.

On nitrogen-deficient soils, supplementary nitrogen has usually been most effective when 20 to 30 pounds per acre were applied in late March or early April. By this date it is usually possible to determine whether or not there has been any winter injury to the wheat. If its survival is doubtful, treatment should be delayed to avoid wasting the nitrogen on dead wheat. It is seldom profitable to fertilize a thin stand.

The effect of the previous crop on wheat stands is shown by tests in Greene county. There wheat after oats produced 34.0 bushels an acre and an additional 4.9 bushels when 20 pounds of nitrogen were added. Wheat after corn yielded 25.4 bushels and made an average gain of 9.6 bushels when 20 pounds of nitrogen were added.1/

At the Carlinville experiment field, wheat after corn in a two-year rotation of corn and wheat with a catch crop has averaged 27 bushels an acre, with an additional response of 3 bushels for nitrogen. Wheat following clover-alfalfa has yielded 44 bushels, with no benefit from extra nitrogen.

Many comparisons of spring and fall applications of nitrogen on crops have shown an advantage for spring treatment. In tests in Macoupin county in which 30 pounds of nitrogen were applied per acre, fall treatments increased yields by 3.5 bushels and spring treatments by 9.8 bushels over the 27.2-bushel yield on untreated land.

Although heavy applications of nitrogen in the fall have sometimes produced good increases in yield, equal results have usually been obtained by applying smaller amounts in the spring. There is little evidence that fall-applied nitrogen will consistently improve winter-hardiness of wheat under Illinois conditions.

1/ Illinois Bulletin 503, page 196.

Applications on nitrogen in the fall or very early spring are sometimes justified because muddy fields make treatments difficult in March or April. If early applications are made, leaching losses can be reduced by using calcium cyanimid or a material that contains ammonium nitrogen.

With normal spring applications, responses have been about the same regardless of the carrier used. The "best buy" is therefore the material that can be applied at the lowest cost per pound of nitrogen. For spring treatment it is seldom practical to put on more than 30 pounds of nitrogen per acre. Larger amounts often cause lodging and injury to legume seedings and rarely give enough yield advantage to warrant their use.

L. B. Miller
2/16/53

DRILLING VS. BROADCASTING OF OATS

Judging by recent queries many oat growers are not sure whether it is better to drill or broadcast oats.

This is an old, old question that has been put to the Illinois Agricultural Experiment Station many times. As long ago as 1909, the Station published Bulletin No. 136, "Methods of Seeding Oats, Drilling and Broadcasting." Since that time the results have been checked against those of other varieties. Other experiment stations in the Corn Belt have also worked on this subject at one time or the other, and all the results are in rather close agreement.

First, let's list the advantages of drilling over broadcasting:

1. A uniform spacing and depth of seeding is insured.
2. An even stand affords a more even growth and ripening.
3. Less seed is necessary.
4. Even spacing results in more competition for the annual weeds.
5. Seeds are covered in the seeding operation.
6. The grass-legume companion crop may be seeded simultaneously.
7. Seedlings are less susceptible to late spring freezes.
8. Yields are higher.

The bulletin released in 1909 showed a net gain of 5.3 bushels for drilling over a three-year period. A test conducted from 1950-1952 with Clinton oats showed a net gain of 6.3 bushels. Seventeen-year tests in Iowa resulted in a 4.1 bushel advantage for drilling.

With these obvious advantages, why are so many oats broadcast in Illinois? The real reason is that a grain drill is not a common implement on many farms in central and northern Illinois. The oat crop is the only one grown on these farms for which a drill would be used. And the relatively low income from oats has dictated the use of cheaper seeding machinery and tools already on hand.

Whether to buy a drill is a decision for the individual farmer to make. By knowing the general price of oats, cost of the desired drill and number of acres grown each year, he can calculate approximately the number of years or crops necessary to pay for a drill. (One can assume approximately a 5-bushel-an-acre increase for drilling.)

For example, if a grower averaged 40 acres of oats and the price averaged 75 cents a bushel, he would have approximately 200 extra bushels, or $150, to apply to the cost of a drill annually.

Agronomically, drilling of spring oats is a highly recommended practice that is supported by much research data. Economically, it is still an unsolved problem for many growers.

J. W. Pendleton
2/1/54

UNIVERSITY OF ILLINOIS COLLEGE OF AGRICULTURE

AGRONOMY FACTS

G-8

LOOSE SMUT OF WHEAT

The amount of loose smut varies from year to year depending on environmental conditions at the time the wheat is in flower. Humid, cool weather accompanied by light showers and dew is favorable for infection.

Infection takes place only during the flowering period of the wheat plant. The wind carries the spores from the smutted head to the floral parts of the healthy head, where they germinate and infect the young embryo (seed) by growing down through the stigma, or female part of the flower. The smut lies in a dormant condition inside the seed during the time it takes it to mature.

At the time the infected kernel is planted and germination takes place, the smut becomes active and grows into the growing point of the wheat plant. By heading time the smut spores have completely replaced the healthy seed, and nothing but a black smutty head appears. Consequently, the amount of infection that occurs in any one year is the result of infection taking place the previous year.

<u>Control</u>. Ordinary seed treatment will not control loose smut. There are some wheat varieties that are resistant to certain physiologic races of the loose-smut fungus, but there is no recommended variety that is resistant to all of the races.

The only control--and we recommend that it be used only by certified seed producers--is the hot-water treatment. This treatment may be applied as follows:

1. Soak 1 bushel of seed in a 2-bushel burlap bag in water at ordinary temperature for 6 hours.

2. Remove presoaked seed (after 6 hours) and immerse in hot water (130° F.) for 10 minutes. (Seed should be agitated during immersion in the hot water.)

3. Remove seed at the end of the 10-minute period, and cool immediately. To cool, run cold water over the heat-treated seed, or empty the seed out of the burlap bags and spread in a thin layer on a concrete slab or canvas. <u>It is important to cool the seed as quickly as possible after treatment</u>.

4. Dry the seed either by placing it in a corn dryer and forcing unheated air through it or by spreading it out in a thin layer and turning it with a scoop every two hours until it is dry enough to resack.

W. M. Bever
3-22-54

STINKING SMUT (BUNT) OF WHEAT

Economic importance. Periodically bunt of wheat becomes a serious disease problem in certain sections of Illinois. The primary reason is that the farmer becomes lax in his seed treatment program and the infection gradually increases. When the amount of infection reaches the point where his wheat is reduced in grade and he has to accept a lower price, he starts to worry about how to control it.

Symptoms. The signs of this disease are usually not evident until the plant is in the heading stage. Under some environmental conditions, together with heavy infection, the plants may be stunted and the leaves mottled as though they were infected with the soil-borne wheat mosaic virus. Ordinarily, however, the only distinguishing symptoms are the slim heads compared with healthy ones. The diseased heads retain their greenish cast longer. The final symptom is the distinctive black powdery mass of spores that occupies the entire kernel.

Life cycle. The black spores (chlamydospore) are carried on the wheat kernels or are present in the soil, where they germinate simultaneously with the wheat seed. The germinating spores penetrate into the tissues of the young wheat seedlings, reach the growing point, and develop along with the host plant until it begins to produce heads. At this time the black spores are produced, resulting in the smutted kernel. In the harvesting process the smutted kernels are broken and the black smut spores become lodged on the sound, or healthy, grain. Also, they are carried by the air to other fields and lodged in the soil.

Effect on quality of seed. Grain from badly smutted fields is conspicuously black, and its value for milling purposes is greatly reduced, because special scouring machinery must be used to clean it. The farmer who produces smutty grain suffers a loss in price in accordance with the amount of smut. The U. S. Grain Standards Act specifies that smutty wheat must be so designated when sold on the market.

There is no experimental evidence that smutty wheat is poisonous when fed to animals. Some evidence has been presented, however, to show that it definitely causes egg production to drop when fed to laying hens.

Control. Treating the seed with one of the mercury coupounds will effectively control any smut that is on the seed. However, no compound has been developed that will effectively control bunt due to soil contamination. For specific information on treating seed to control bunt, write to the Department of Agronomy, University of Illinois, Urbana.

W. M. Bever
4-19-54

SEED TREATMENTS FOR SMALL GRAINS

A proper fungicidal seed treatment is a sure control for stinking smut (bunt) of wheat, the smuts of oats, and two of the smuts of barley. In addition, Illinois tests show that it is usually a paying proposition for the control of seedling blight.

In experiments with smut-free wheat and oats, some of the treated rows have unmistakably shown better vigor in occasional years. Even in some years when such differences were not apparent, yield increases of as much as five bushels an acre occurred. In some other years yields did not increase, but these cases were in the minority.

When seed is used that came from a field in which any smut (except loose smut) has been seen, treatment becomes especially urgent. A small percentage of smut in one year may mean a heavy infection the next year. Barley, particularly winter barley, should always be treated because it is subject not only to smut and seedling blight, but also to a damaging disease called "stripe," which can be controlled.

Loose smut of wheat and barley cannot be controlled by fungicidal seed treatment. The principal controls are resistant varieties and the hot-water treatment. The latter is difficult to use and usually causes some injury to germination. These loose smuts can be identified by the fact that practically all of the smut spores have blown away from the heads by the time the grain is mature, leaving only the bare rachis (see Agronomy Facts G-8.)

There are other diseases of oats and wheat not mentioned above that can be controlled more or less by treatment, but in general they appear to be of minor importance in Illinois at present. Sometimes unforeseen diseases develop suddenly and severely, as was the case with Victoria (Helminthosporium) blight of oats from 1946 to 1950.

Improvements have been made during the past decade in fungicides for treating seeds and in methods of applying them. Ceresan M and Panogen are the commercial names of the two compounds recommended by the Illinois Agricultural Experiment Station for treating small grains. Both contain mercury and are therefore poisonous. For this reason they should be used in a well-ventilated place.

Under certain conditions Ceresan M may cause some reduction in yield by damaging the seed. Wheat is more sensitive to mercury damage than oats are, and barley appears to be intermediate. Damage may occur (a) when the moisture in the grain is too high or (b) in dry grain (12 percent moisture) when the dosage is too high in relation to the length of time the grain is held after treating and before sowing. In no case should more than 1/2 ounce per bushel be used; and if the seed is treated two or more weeks before sowing, the rate should be 1/4 ounce. The two methods are equally efficient for smut control: 1/4 ounce acting for two weeks is just as effective as 1/2 ounce acting for two days.

Panogen causes somewhat less injury to the grain than Ceresan M, according to Illinois tests. But it is also somewhat more volatile. To protect the workmen, it is therefore particularly important that Panogen be used in a well-ventilated place. Because there is little danger of injuring the grain, a dosage of 3/4 ounce of Panogen is recommended, regardless of how long the treated grain is to be stored, and it is best to let the treated seed remain in bags or a pile at least three days before planting.

Both Ceresan M and Panogen can be obtained in a double-strength formula. When this stronger material is used, the dosage should be cut in half.

Ceresan M is a dry powder that can be used either dry or as a slurry. When it is used dry, the operator should wear a respirator. Panogen is a red liquid that can be diluted with water for the slurry machine or used full strength with the special Panogen treating machine. Either fungicide can also be used in a batch treater, such as a small concrete mixer, a barrel churn, or a steel drum fitted with a diagonal axle, hinged lid, and crank. In this case Ceresan M should be applied dry, using a suitable measuring spoon, but Panogen should first be diluted, 1 part to 4 parts water, and 1/2 cup (4 ounces) of the dilution should be used per bushel for wheat, oats, and barley.

The slurry machines (there are several makes) and the special Panogen machine have the following advantages over the machines that use the dry powder:

(a) Liquids can be metered more accurately than powder, making it possible to apply the desired dosage more precisely.

(b) Usually materials that are applied wet stick better than dusts.

(c) In fungicides that are sold as dry powders, little of the dust gets into the air to bother the workmen when the slurry machines are used. The grain moisture is increased about 1/2 of 1 percent by the slurry treatment, but no drying is necessary provided the moisture content was low at the start.

Besides Ceresan M and Panogen, there are a few other fungicides that may be equally effective for wheat. Some of them are Agrox, Vancide 51, Setrate, Pentrate, and Geitrete. However, these materials are not satisfactory for some of the diseases of oats and barley. Making additional recommendations just for wheat would only cause unnecessary complications and might lead to confusion. Treatments used for corn, such as Arasan, Orthocide 75, Ortho Seed Guard, DuPont I and D, and Thiram Naugets, are not satisfactory for small grains.

Mergamma is a seed dressing for wheat that combines both fungicidal and insecticidal ingredients. The latter is included especially for wireworm control. In a 10-month storage test of treated seed, Mergamma caused more injury to germination than any other commercial or experimental treatment in the test. It is doubtful whether there is sufficient wireworm damage to small grains in Illinois to warrant the use of an insecticide.

Benjamin Koehler
5-17-54

SOYBEAN VARIETIES

The following varieties of soybeans are adapted to Illinois:

Northern: Blackhawk, Hawkeye
Central: Hawkeye, Adams, Lincoln, Chief
Southern: Chief, Wabash, Perry

Short descriptions are given below for the varieties recommended for Illinois, as well as for some varieties that are not recommended but are receiving publicity in the state.

Recommended

Blackhawk. Selected from the cross Mukden x Richland developed by Iowa in cooperation with U. S. Regional Soybean Laboratory. Pubescence gray, flowers white, pods two to three seeded, seed medium in size and straw colored with light brown hilum. Medium oil content. Matures about a week earlier than Hawkeye, grows about two inches shorter, and is comparable with Hawkeye in lodging resistance.

Hawkeye. Selected from the cross Mukden x Richland by Iowa in cooperation with U. S. Regional Soybean Laboratory. Pubescence gray, flowers purple, pods two to three seeded, seed large in size and straw-yellow with black hilum. Medium oil content. Matures about a week earlier than Lincoln and grows about the same height. Yield has been excellent in central Illinois but disappointing on the light soils of southern Illinois, where it has been tried as an early variety to precede wheat. Lincoln appears to be much better adapted to this purpose in southern Illinois.

Adams. Selected from a cross between Illini and Dunfield by Iowa in cooperation with U. S. Regional Soybean Laboratory. Pubescence gray, flowers white, pods two to three seeded, seed medium in size and straw colored with buff to light brown hilum. High oil content. Adams splits the difference between Hawkeye and Lincoln in maturity, being two to three days later than Hawkeye and two to three days earlier than Lincoln. It is slightly better than Lincoln in lodging resistance, grows slightly shorter, and has a good yield record in north-central and central Illinois.

Lincoln. Selected from a cross between Mandarin and Manchu by Illinois in cooperation with U. S. Regional Soybean Laboratory. Pubescence tawny, flowers white, pods two to four seeded, seed medium sized and straw-yellow with black hilum. High oil content.

Chief. Developed by Illinois from a cross between Illini and Illinois type No. 95. Pubescence gray, flowers purple, pods two to three seeded, seed small and straw-yellow with slate to brown hilum. Medium in oil content. Chief averages seven to eight days later than Lincoln in maturity, normally grows taller, and does not stand so well. A typical field of Chief may look somewhat lodged, but will have scattered plants standing erect.

Wabash. Selected by Illinois and Indiand in cooperation with U. S. Regional Soybean Laboratory from a cross between Dunfield and Mansoy. Pubescence gray, flowers white, pods two to three seeded, seed medium in size and straw-yellow

with light-brown hilum. High in oil content. Wabash averages about one to two days later than Chief in maturity, stands better, normally grows several inches shorter, and equals or exceeds it in yield in southern Illinois.

Perry. Developed from the cross Patoka x L7-1355 by Indiana in cooperation with U. S. Regional Soybean Laboratory. Pubescence gray, pods dark gray and two to three seeded, flowers purple, seed large and yellow with black-brown hilum. Oil content high. Perry averages four to five days later than Wabash in maturity. It is very resistant to lodging, grows about the same height as Wabash, and has an exceptionally high yield record in southern Illinois

Not Recommended

Bavender or Bavender Special. Selected by Mr. Bavender of Whitten, Iowa, from a cross between Mukden and a North Carolina variety. Pubescence tawny, flowers both purple and white, pods three and four seeded, seed straw-yellow with both black and brown hila, seed size and oil content medium. Bavender matures two to three days earlier than Lincoln, has about the same height, and has a good yield record in Illinois, but is not recommended because it is extremely susceptible to lodging.

Cypress No. 1. Selected from Korean by Cypress Land Farms Company, St. Louis, Missouri. Matures six to eight days later than Lincoln, grows about the same height, and is extremely susceptible to lodging. Not tested long enough in Illinois to be compared with Lincoln in yield.

Early Korean. Introduced from the Orient by the Dominion Experiment Station, Ontario, Canada. Unusually large yellow seed with black hilum. Matures two or three days earlier than Hawkeye, grows about six inches shorter, and equals it in resistance to lodging. Lower in yield and oil content than Hawkeye in Illinois.

Monroe. Developed from a cross between Mukden and Mandarin by Ohio in cooperation with U. S. Regional Soybean Laboratory. Pubescence gray, flowers purple, pods two to three seeded. Medium-sized seed, straw-yellow with colorless hilum. Low oil content. Monroe averages three to four days earlier than Blackhawk, does not stand so well, and has not equaled it in yield in Illinois.

USDA Farmers' Bulletin No. 1520 contains short descriptions of most of the soybean varieties grown in the United States.

W. O. Scott
1/12/53

S-1
Revised

SOYBEAN VARIETIES

The following varieties of soybeans are adapted to Illinois:

Northern: Blackhawk, Harosoy, Hawkeye, Adams

Central: Harosoy, Hawkeye, Adams, Lincoln, Clark

Southern: Clark, Wabash, Perry

Short descriptions are given below for the varieties that are recommended for Illinois, as well as for some varieties that are not recommended but are receiving publicity in the state.

Recommended

Blackhawk. Selected from the cross Mukden x Richland developed by Iowa in cooperation with the U. S. Regional Soybean Laboratory. Pubescence gray, flowers white, pods 2- to 3-seeded, seed medium in size and straw colored with light brown hilum. Medium oil content. Matures about a week earlier than Hawkeye, grows about 2 inches shorter, and is comparable with Hawkeye in lodging resistance.

Harosoy. Developed at the Harrow, Ontario, Canada Station from a selection Mandarin x AK backcrossed to Mandarin. Pubescence gray, flowers purple, pods dark gray, 2- to 3-seeded, seed large in size, yellow with colorless hilum. Medium oil content. Matures 2 to 3 days earlier than Hawkeye, grows about same height and is slightly less lodging resistant than Hawkeye. For the past 3 years it has been the highest yielding variety in northern Illinois. At Urbana it has equaled Hawkeye in yield.

Hawkeye. Selected from the cross Mukden x Richland by Iowa in cooperation with the U. S. Regional Soybean Laboratory. Pubescence gray, flowers purple, pods gray, 2- to 3-seeded, seed large in size and straw-yellow with black hilum. Medium oil content. Matures about a week earlier than Lincoln and grows about the same height. Yield has been excellent in central Illinois but disappointing on the light soils of southern Illinois, where it has been tried as an early variety to precede wheat. Lincoln appears to be much better adapted to this purpose in southern Illinois.

Adams. Selected from a cross between Illini and Dunfield by Iowa in cooperation with the U. S. Regional Soybean Laboratory. Pubescence gray, flowers white, pods gray, 2- to 3-seeded, seed medium in size and straw colored with buff to light brown hilum. High oil content. Adams splits the difference between Hawkeye and Lincoln in maturity, being 2 to 3 days later than Hawkeye and 2 to 3 days earlier than Lincoln. It is slightly better than Lincoln in lodging resistance, grows slightly shorter, and has a good yield record in north-central and central Illinois.

Lincoln. Selected from a cross between Mandarin and Manchu by Illinois in cooperation with the U. S. Regional Soybean Laboratory. Pubescence tawny, flowers white, pods brown, 2- to 4-seeded, seed medium sized and straw-yellow with black hilum. High oil content.

Chief. Developed by Illinois from a cross between Illini and Illinois type No. 95. Pubescence gray, flowers purple, pods gray, 2- to 3-seeded, seed small and straw-yellow with slate to brown hilum. Medium in oil content. Chief averages 7 to 8 days later than Lincoln in maturity, normally grows taller, and does not stand so well. A typical field of Chief may look somewhat lodged, but will have scattered plants standing erect.

Clark. Clark was developed by Indiana in cooperation with the U. S. Regional Soybean Laboratory from the backcross Lincoln x (Lincoln-Richland). Pubescence brown, flowers purple, pods brown, 2- to 3-seeded, seeds medium to large in size and straw-yellow with black hilum. High oil content. Clark grows to about the same height as Lincoln but matures about a week later. It is superior to Lincoln in lodging resistance. It is equal or superior to Wabash in this respect. Under Illinois conditions Clark has been higher yielding than Lincoln, Wabash, and Perry at the following test locations: Urbana, Stonington, Trenton, and Eldorado, Illinois. Seed is available in Illinois for 1954 planting.

Wabash. Selected by Illinois and Indiana in cooperation with the U. S. Regional Soybean Laboratory from a cross between Dunfield and Mansoy. Pubescence gray, flowers white, pods gray, 2- to 3-seeded, seed medium in size and straw-yellow with light brown hilum. High in oil content. Wabash averages about 1 to 2 days later than Chief in maturity, stands better, normally grows several inches shorter, and equals or exceeds it in yield in southern Illinois.

Perry. Developed from the cross Patoka x L-7-31355 by Indiana in cooperation with the U. S. Regional Soybean Laboratory. Pubescence gray, pods dark gray and 2- to 3-seeded, flowers purple, seed large and yellow with black-brown hilum. Oil content high. Perry averages 4 to 5 days later than Wabash in maturity. It is very resistant to lodging, grows about the same height as Wabash, and has an exceptionally high yield record in southern Illinois.

Not Recommended

Bavender or Bavender Special. Selected by Mr. Bavender of Whitten, Iowa, from a cross between Mukden and a North Carolina variety. Pubescence tawny, flowers both purple and white, pods 3- and 4-seeded, seed straw-yellow with both black and brown hila, seed size and oil content medium. Bavender matures 2 to 3 days earlier than Lincoln, has about the same height, and has a good yield record in Illinois, but is not recommended because it is extremely susceptible to lodging.

Cypress No. 1. Selected from Korean by Cypress Land Farms Company, St. Louis, Missouri. Matures 6 to 8 days later than Lincoln, grows about the same height, and is extremely susceptible to lodging. Not tested long enough in Illinois to be compared with Lincoln in yield.

Early Korean. Introduced from the Orient by the Dominion Experiment Station, Ontario, Canada. Unusually large yellow seed with black hilum. Matures 2 to 3 days earlier than Hawkeye, grows about 6 inches shorter, and equals it in resistance to lodging. Lower in yield and oil content than Hawkeye in Illinois.

Monroe. Developed from a cross between Mukden with Mandarin by Ohio in cooperation with the U. S. Regional Soybean Laboratory. Pubescence gray, flowers purple, pods 2- to 3-seeded. Medium-sized seed, straw-yellow with colorless hilum. Low oil content. Monroe averages 3 to 4 days earlier than Blackhawk, does not stand so well, and has not equaled it in yield in Illinois.

USDA Farmers' Bulletin No. 1520 contains short descriptions of most of the soybean varieties grown in the United States.

W. O. Scott
1-25-54

UNIVERSITY OF ILLINOIS · COLLEGE OF AGRICULTURE

AGRONOMY FACTS

S-2

SOYBEAN DISEASE AND THE WEATHER

What can we expect from soybean diseases this season? This question is asked almost every year in March or April. Unfortunately, there is no ready answer. From past experience we know several diseases that appear each year, but we cannot foretell how prevalent or how severe they will be. The weather has a definite influence in certain phases of disease development.

Observations over the years show that certain diseases are closely associated with specific conditions of rainfall and temperature. Once a particular weather pattern develops, we have some idea of what to expect in the line of disease outbreaks. We must remember, however, that showers may be extremely localized and thus their effect may be limited to small geographic areas. Likewise a disease-inciting organism must be present as the first requisite for infection.

With these reservations, we can list certain conditions as they apply to soybean diseases.

<u>Frequent rain and cool weather</u> favor the development of bacterial blight, which usually occurs in Illinois in June and early July. If cool weather persists and showers are frequent, new infections may be found throughout July. The disease recedes rapidly with the onset of high temperatures.

If rain is frequent and heavy enough to keep the soil wet, Rhizoctonia root rot is likely to develop on young soybean plants in June. If the soil remains overly wet, the disease may kill older plants through July, since it operates over a wide temperature range.

<u>Warm, moist weather</u> is likely to encourage the development of Septoria brown spot, which first appears on the primary leaves and later spreads to the upper leaves.

<u>Rain and warm weather</u> combine to favor the development of bacterial pustule, which usually appears during the first two weeks in July. This disease persists through mid-August, although maximum infection is usually attained near the end of July.

<u>Cool weather in August</u>, especially during the first half of the month, favors the development of brown stem rot. In this period the fungus progresses inside the stem. If such conditions are followed by a warm, dry period late in August or early in September, the leaves are likely to wither and turn brown as a result of the disease. Except for this latter stage, rain has little to do with the development of brown stem rot.

<u>Hot, dry weather</u> is unfavorable for most soybean diseases. Consequently when such conditions prevail throughout much of the growing season, soybeans show little infection. One exception, however, is charcoal rot. This disease is favored by hot, dry weather, especially in combination with poor soil. Charcoal rot is usually found after midsummer, mostly in the southern half of Illinois.

In order to treat these disease-weather relationships as briefly as possible, the diseases are listed here by their common names. The symptoms, causal organisms, and other pertinent facts may be found in Illinois College of Agriculture Circular 676, Soybean Diseases in Illinois.

D. W. Chamberlain
Pathologist, U.S.
Dept. of Agriculture
4/27/53

WHEN TO SEED SOYBEANS

For years farmers have debated about what is the best date to seed soybeans. Most of them have established their patterns of seeding on the basis of either experience or custom.

In the early years of soybean production in Illinois, a large part of the crop was grown solid, like oats or wheat. This meant that two or three crops of weeds had to be killed before the seed was planted. This thorough preparation usually delayed seeding until after corn-planting time. Since most of the farm work was then done with horses or mules, final seedbed preparation was often not completed until about the first of June.

Medium Early Yellow or Ito San was the variety that was grown most extensively in that early period. Because of its early maturity, Ito San could be planted in June and it would still mature. This characteristic, together with the need for more time to prepare the seedbed, established a pattern of relatively late seeding for soybeans.

This practice has, however, gradually been changing. Introduction of power machinery, the combine, and new and better adapted varieties made it necessary for many experiment stations to examine cultural practices. As a result, studies were undertaken in the late 20's to determine the best time to seed soybeans.

For six years (1926-1931) the University carried on a study of this kind with 12 different varieties varying in maturity from a very early black soybean to late-maturing yellow and green beans. Seedings were made at six different dates between May 1 and June 20 at approximately 10-day intervals.

Results of these tests showed that, for all varieties taken together, yields from seedings made in May averaged 3.1 bushels, or 15 percent, more per acre than yields from the three June seedings. In fact, with the single exception of the very early Wisconsin Black, the highest average yield of each variety was also obtained from one of the May seedings.

There was very little difference in yield among the three May seedings. The highest was from the May 20 seeding, the second highest from the May 10, and the lowest from the May 1. But the difference was only .5 bushel between the highest and the lowest.

At a later date the U. S. Regional Soybean Laboratory, located on the University campus, inaugurated a cooperative test between the states of Iowa, Illinois, and Indiana. These trials, conducted for a period of three years, compared five soybean varieties seeded at five different dates in three locations (Ames, Iowa; Urbana, Illinois; and West Lafayette, Indiana). Here, as in the earlier Illinois trials, the test included an early and a late variety as well as three medium-maturing varieties that were more nearly adapted to the region.

An average of all varieties tested showed relatively little difference in yield for plantings from the first three dates--May 1, 12, and 23. There was, however, a more marked drop in the averages for the two June plantings. The early variety, Mandarin, which is about one week earlier than Blackhawk, produced its highest yield for the June 14 planting. On the other hand, the latest variety, Boone, when planted on June 14, produced only 61 percent of the top yield for that variety, which was obtained by seeding on May 1.

The three varieties (Richland, Mukden, and Dunfield), considered to be adapted to all three locations, gave highest average yields for the May 1 seeding, next highest for the May 12, and third highest for the May 23. The over-all difference, however, was only 1.2 bushels. This would suggest that it is possible to destroy at least two crops of weeds by additional seedbed preparation and still get beans into the ground by about May 20 without suffering severe losses in yield.

Trials made by the U. S. Regional Soybean Laboratory and cooperating states showed certain other results that will be of interest to the farmer:

1. Maturity was retarded about one day for each three days' delay in planting.
2. All dates considered, yields were highest for varieties adapted to use of the full growing season.
3. In an average of all varieties, their maximum height was reached by plants from the second planting date, May 12, and height diminished gradually for each succeeding date.
4. Amount of lodging was not significantly affected by different dates of planting.
5. On the average, oil content was reduced slightly by delayed planting, but there was also some difference due to varietal reaction.
6. Protein content was not appreciably affected by delayed planting.

The following data taken from USDA Technical Bulletin 1017 show the response of each of the varieties to the different dates of planting:

Mean Seed Yields Per Acre of 5 Varieties of Soybeans
Planted on 5 Dates at 3 Locations for 3 Years
1940-1942

	Yield for variety planted--					
Variety	May 1	May 12	May 23	June 3	June 14	Mean
	bu.	bu.	bu.	bu.	bu.	bu.
Mandarin	25.5	26.6	26.2	26.5	26.1	26.2
Richland	32.2	31.5	32.3	30.5	29.0	31.1
Mukden	34.1	33.9	31.9	31.4	28.2	31.9
Dunfield	33.6	33.1	32.6	29.8	27.6	31.3
Boone	30.3	28.0	26.8	22.2	18.7	25.2
Mean	31.2	30.6	30.0	28.1	25.9	29.1

The most recent date-of-planting studies from which data are available were carried on by the U. S. Regional Soybean Laboratory at Urbana, Illinois, during the seasons of 1951 and 1952. The following data are of special interest because several of the currently popular varieties were included in these studies:

Variety	Date planted May 1	May 15	May 29	June 12
	bu.	bu.	bu.	bu.
Blackhawk	34.2	37.8	37.4	36.1
Hawkeye	38.9	43.5	38.7	38.3
Adams	42.4	45.8	42.3	36.9
Lincoln	43.4	43.2	38.6	39.0
L6-2132	46.6	44.8	40.4	41.0
Wabash	41.8	38.8	35.7	31.2
Perry	43.9	39.9	36.9	35.6
L6-5679	34.8	34.8	29.8	25.1
Mean	40.8	41.1	37.5	35.4

The highest average yield for the eight varieties studied indicates that mid-May is the best planting date. A study of the individual varieties indicates that Blackhawk, Hawkeye, and Adams, the 3 earliest in this group, were best when planted on May 15 or May 29, the former date having a slight but not significant advantage. Lincoln, a full-season variety at Urbana, yields equally well May 1 or May 15, but later seedings reduce yields. The other four varieties, all of which are from a week to 10 days or more later than Lincoln, would seem to require early May planting for maximum yields.

J. C. Hackleman
4-26-54

EFFECTIVE METHODS AND RATES OF SEEDING SOYBEANS

When soybeans were first grown in Illinois, many people considered them either a forage or hay crop and used them as a substitute for part of the oats in the rotation. In either case the crop was seeded with a grain drill in rows 7 or 8 inches apart. Harvesting was done with the mower or the binder, depending on the use of the crop.

As soybean acreage increased and combining became the preferred method of harvesting, producers were quick to ask how row seedings would compare in yield with broadcasting or drilling, because it was easier to control weeds in row seedings. This interest in row seeding caused the experiment stations to set up tests to compare yields of row and solid seedings and to determine the best seeding rates.

In an experiment conducted at the Illinois Station and reported in Bulletin 462, Illini soybeans grown in 24-inch rows at rates varying from 30 to 110 pounds an acre were compared with beans drilled in 8-inch rows at rates of 50 to 210 pounds. The following conclusions were drawn from these tests, which covered a period of five years (1928-1932):

1. Row seedings outyielded solid or drill plantings by an average of 17.4 percent.

2. Optimum seeding rate for drilled beans was 1 1/2 to 2 bushels an acre.

3. Optimum amount of seed for row plantings was 50 to 70 pounds an acre.

4. Row seedings had a higher percentage of normally mature pods at harvest than either drilled or broadcast seedings.

5. Row seedings were also standing more nearly erect at harvest.

More recent tests at Corn Belt experiment stations have attempted to determine proper width of row and optimum rate of seeding with present-day varieties. Tests made at Illinois, Indiana, Iowa, and Ohio show that beans in 21- to 24-inch rows averaged 2 to 4 bushels more than those in 40- to 42-inch rows.

Subsequent trials have shown that the character of growth of the variety under tests affects optimum width of row. The shorter and less branching the plants, the narrower the row. Tall-growing, branching types of plants can be seeded in wider rows with no significant reduction in yield. Varieties with growth habits like Lincoln, Hawkeye, Adams, and Clark will not suffer serious losses in rows up to 36 inches wide.

Most farmers object to narrow-row spacing because they have to change the adjustments on their planters and cultivating equipment. Many of them say they would rather take a reduction in yield of beans.

One way to avoid changing your machinery and yet reduce the average width of row, if you have a two-row planter, is to plant the two rows of beans at the normal corn-row width and shorten the gauge or marker. You will then get two rows of normal width, but the space between the pairs of rows will be narrower. The exact amount to shorten the marker will depend on the width of the tractor tread--if you expect to use a tractor in cultivating.

The answer to how much seed to plant per acre will depend somewhat on width of row and also on quality of seed. On soils that tend to crust, thicker planting will usually insure a more satisfactory stand, as the seedlings tend to help one another break the crust. As a general rule, 8 to 12 seeds per foot of row should be adequate.

The following data were obtained at the Iowa Experiment Station in a test covering five years (1939-1943) in which five varieties were seeded at different seeding rates in 32-inch rows.

Another interesting result reported b the Iowa investigators was that each 1/2 bushel increase in seeding rate adde three plants per foot of row, and wit this increase came approximately an percent increase in amount of lodging.

	Rate of planting (pounds per acre)				
	36	60	84	108	13
Average yield, bushels	27.0	28.1	28.6	28.2	28.
Net yield (average yield minus seed used), bushels	26.4	27.1	27.2	26.4	26.
Plants per foot of row	6	9	11	13	16

You will note that the net yield (average yield minus seed used) did not differ for the 60- and 84-pound rates where the stands were 9 and 11 plants per foot of row, respectively. Also of interest is the fact that net yield was reduced only .7 bushel when average number of plants per foot of row was reduced by one-third, from 9 plants to 6, at 36 pounds of seed per acre.

Since extra-heavy seeding rates do no increase net yield, but do tend to in crease amount of lodging, only enoug beans should be seeded to make the seedlings thick enough to help each othe emerge. This will probably mean planting 8 to 12 good, germinable seeds pe foot of row. Such a stand will be adequate even if one or two plants per foo or row are lost during early cultivation

J. C. Hacklema
5/3/54

LOSS OF PLANT NUTRIENTS BY LEACHING FROM THREE ILLINOIS SOILS

Plant nutrients are removed from soils by harvested crops, by erosion, and by leaching. Attempts are frequently made to estimate the total amount of plant nutrients removed from soils to use as a basis for fertilizer recommendations. The amount of nutrients removed by crops can be determined rather accurately, but losses by leaching and erosion are less easy to figure. Improved methods for determining nutrient losses are needed.

The following figures on leaching losses from three Illinois soils were obtained by a method that more nearly approaches field conditions than those previously used. Because in this method the natural soil structure was not destroyed, the results should be more reliable than those obtained on disturbed soil.

The three soils for which results are given vary widely in both physical and chemical properties. This difference is reflected in the leaching losses. Runoff was permitted whenever the rate of rainfall exceeded the capacity of the soil to absorb it.

The soils have been kept bare since 1935. No lime or fertilizers have been added. Phosphorus losses are not included in the results because only traces of this nutrient were found in the drainage water.

The results reported here are for silt loam soils that have been developed under grass vegetation. Saybrook and Muscatine, which are dark colored and highly productive soils, occur extensively in the northern two-thirds of Illinois. Saybrook occurs in the northeastern part; and Muscatine, mostly in the western and northwestern parts. Cisne is a gray-colored soil having a claypan subsoil that is very slowly permeable to water. It occurs in the southern one-third of the state.

For further description of these soils, see Illinois Mimeo. AG1443, Illinois Soil-Type Descriptions. For further information on this project, see Journal of American Society of Agronomy, volume 29:917-923, 1937, and volume 34:830-835, 1942. A complete summary of the entire project will be published in 1953.

Average Annual Leaching Losses, Runoff, and Drainage, for the 10-Year Period 1942-1951

Soils	Calcium	Magnesium	Potassium	Sodium	Nitrogen	Sulfur	Runoff	Drainage (Internal)
	(Pounds per acre)						(Percent)	
Saybrook	181.2	83.8	2.2	11.3	103.6	50.3	9.3	34.3
Muscatine	133.9	70.3	1.4	9.8	77.5	48.6	14.8	28.9
Cisne	15.0	10.0	2.4	39.6	31.4	1.4	32.3	3.0

Note: Average annual precipitation, 40.76 inches.

R. S. Stauffer
1/12/53

KRILIUM AND OTHER SOIL CONDITIONERS

Krilium is one of twenty or more commercial soil conditioners manufactured to treat and improve soils that have a tendency to become hard, compact, crusty and cloddy when dry. These soil conditioners, which are all similar, have proved to be extremely effective in fulfilling their purpose, but they are too expensive for general use on farm land.

What Do They Cost?

Although exact prices will not be quoted, it appears that manufacturers of the polyacrylate type[1/] of soil conditioners must sell them between $1.00 and $2.50 per pound of active ingredients in order to make a profit. Experiments show that from 200 to 1,000 pounds are required to bring about the desired changes in the top six inches of an acre of clayey soils. At these prices and rates of application, it is obviously impractical to condition the plow depth of large areas of farm land.

There is a widespread impression that future large-scale production of these soil conditioners might make it possible to reduce prices to a small fraction of present prices. The outlook for such reduction is not good, however, especially if the present products and raw materials continue to be used. Here is the reason:

Acrylonitrile, the raw material used in the manufacture of the most commonly used soil conditioners, is very expensive. Facilities for manufacturing it are not sufficient to meet the demand, and attempts to import the material have not been successful. Acrylonitrile is also used in the production of important plastics, fibers, and fabrics. Orlon, a much-desired fabric in clothing, is one of them. The demands for Orlon and other similar products containing acrylonitrile may actually force the manufacturers to raise prices temporarily on soil conditioners.

How Long Will They Last?

The polyacrylate soil conditioners are extremely resistant to decay. Field experiments show that applications made over three years ago are still as effective as when they were first applied. More severe laboratory and greenhouse tests show that their effects will last for many years.

What Is Their Best Use at Present Prices?

High price will limit the use of soil conditioners to situations where special advantages can be realized. They may be expected to find uses in lawns, gardens, truck farms, golf greens, and ornamental and greenhouse plantings. They may also be useful in protecting small spots from erosion while grass stands are being established. Treating small areas or strips over plantings may prove practical as an aid to emergence of certain seedlings that are unfavorably affected by crust formation on light-colored clayey soils.

How to Apply

Soil conditioners may be applied either in solution as a spray or in powder form. In either case the moisture content of the soil must be such as to permit the conditioner to mix immediately and thoroughly with the soil. A rototiller is the most effective implement to use for this operation.

Applying soil conditioners to cloddy or crusted soils without mixing may cause more harm than good. The reason is that

1/ The most common type of soil conditioner on the present market.

they affect only the soil which they contact and do not move into the clods and crusts after they have reacted with the surface. The over-all effect of unmixed applications is to stabilize clods and crusts, making them resistant to breakage during subsequent cultivations. If soil conditioners are to correct undesirable subsoil conditions, they must be thoroughly mixed with the subsoil.

How They Affect the Soil

Soil conditioners make compact, cloddy, or crusty soils more crumbly and friable. The soil becomes more porous, more permeable to air and water, and easier to till.

Value to Soil Research

Research on soil conditioners has not provided a solution for large acreages of farm land, but it has indicated the kind of compounds that are effective in changing the physical properties of soils. With this knowledge, further research in organic chemistry may yield better and less expensive soil conditioners. It may also suggest a way of converting crop residues and manure into more effective soil conditioners.

J. E. Gieseking
1/12/53

FUNDAMENTALS OF MAINTAINING SOIL TILTH

Soil physical conditions are important primarily as they make it possible (1) for air and water to move into and through the soil, (2) for the plant roots to pass through and make use of the soil, and (3) for the soil to hold enough water in a form available for plants to use.

These conditions are affected primarily by the texture, degree of compaction. and state of aggregation of the soil.

Since cultural practices have little or no effect on soil texture, attempts to alter air and water relationships and suitability of the soil for effective plant root development must be measured by the effects of such practices on soil compaction and aggregation.

Soils that are well aggregated have a desirable range of ~~poor~~ sizes that permit water to infiltrate readily and spread rapidly through the rooting zone. A significant proportion of large pores also allows excess water to be removed quickly from the soil and permits the exchange of gases through the pores. This exchange is essential for maintaining in the soil a supply of oxygen adequate for normal root development and for such important processes as nitrification and nitrogen fixation.

If there is not enough oxygen in the soil, root growth and extension are greatly reduced and absorption of nutrients and water by the roots is seriously impaired. In addition, reduced compounds may appear in quantities sufficient to disrupt the balance between the plant nutrients or to cause the soil to become toxic.

Soils that are highly compact either naturally or because of continued mismanagement do not have enough, or large enough, soil pores to permit water and air to move rapidly into and through them. Thus it appears that, basically, inadequate soil aggregation and excessive compaction both have a significant effect on plant growth, because the size and distribution of the soil pores in turn limits the movement of air and water.

One of the most important factors affecting soil aggregation and the susceptibility of the soil to compaction is the amount of readily decomposable organic matter it contains. The fact should be emphasized that it is the <u>rapidly decomposing fraction</u> rather than the total percentage of organic matter that is important.

There is plenty of experimental evidence to show that the rate of organic matter decomposition is highly correlated with soil aggregation. The reason is that certain intermediate biological decomposition products that are formed during the breakdown of plant residues are very effective aggregating agents. In fact, it was the discovery of the remarkable effectiveness of these products that led to the intensive research on related synthetic compounds, such as the polyacrylonitriles, polyvinylacetates, etc. This research in turn led to the development of Krilium and other synthetic soil conditioners.

Unfortunately, these naturally produced aggregating compounds are rather unstable and hence not permanently effective. The result, of course, is that readily decomposable organic materials must be incorporated into the soil at frequent intervals if they are to be effective in supplementing those produced naturally.

Tillage and impact of raindrops on the soil also destroy the soil aggregates and increase compaction. Damage from tillage is greatest when the soil is

excessively moist. Although tillage usually reduces soil compaction temporarily, the resultant increase in biological activity hastens the breakdown of the aggregating compounds in the soil, causing a net reduction in aggregation.

Soil aggregates have their lowest stability or strength when saturated with water. This lowered stability, coupled with the impact exerted on the soil by raindrops, causes considerable destruction of aggregates in the surface soil. Upon drying, this dispersed soil frequently forms a compact crust that makes it difficult for air and water to enter the soil and in some instances prevents seedlings from emerging.

In light of these principles, it is possible to evaluate, in relative terms, the probable effects that cropping systems or soil management practices will have on soil physical conditions. Practices that cause large amounts of readily decomposable organic matter to be incorporated into the soil will do most to improve soil aggregation and reduce susceptibility to compaction.

Similarly, management systems that minimize intensive tillage, particularly during periods of high soil moisture, and that maintain a vegetative cover on the land during a large part of the year will be most conducive to the maintenance of good soil physical condition.

At present there is not enough information to make it possible to predict the effects of varying soil conditions on plant growth and crop yields. It seems clear, however, that as we raise the fertility level of our soils, increase the yield potentials of varieties, and learn more effective methods of planting and harvesting crops and controlling plant diseases and pests, we shall find it necessary to give more attention to the physical conditions of soils as factors which determine the ceiling on crop yields.

Only when we have developed effective methods of characterizing the significant soil physical conditions and have established tolerance limits and response curves for those conditions will it be possible to make a completely rational approach to the problem of evaluating management practices in relation to soil condition.

M. B. Russell
3/16/53

PUBLISHED INFORMATION ON THE CHARACTERISTICS AND DISTRIBUTION OF DIFFERENT KINDS OF SOILS IN ILLINOIS

Soil reports and detailed soil maps have been published for 74 Illinois counties (listed at end). The detailed soil maps indicate the distribution of the different soil types in the county. In the text of each county soil report, the different soil types shown on the map are described, and suggestions are made concerning their use and management. Mimeographed descriptions of soil types accompany the detailed soil maps for Alexander, Henderson, and Pulaski counties. There is also a soil association map and mimeographed publication, AG1494, entitled "Soils of Cook County," which describes the soils in that area.

Much new information about soils has been obtained since the older soil maps and reports were printed. This is especially true of Soil Reports Nos. 1 to 53, inclusive, and the detailed soil maps without soil reports for Crawford, Franklin, Monroe, and White counties, which were published before 1933. For many areas this newer information is necessary if the maps and other soil information in the reports are to be correctly interpreted. Help in making these interpretations can be obtained by studying Illinois Publication AG1443 entitled "Illinois Soil Type Descriptions" or by writing to the Department of Agronomy, University of Illinois, Urbana.

The soils in northeastern Illinois are quite variable and those which are developed from thin loess over fine-textured glacial till present some management problems that are more difficult to correct than in many other parts of the state. Some of the characteristics and management requirements of these slowly permeable soils are discussed in the following three publications:

C663 - Handling Northeastern Illinois Soils
C604 - Shall We Fall-Plow or Spring-Plow in Northeastern Illinois?
B540 - Costs and Benefits From Soil Conservation in Northeastern Illinois

Information on the productivity and relative earning capacity of different kinds of soil, which will be helpful to operators, owners, and prospective purchasers of farm land, is published in the two bulletins listed below:

B522 - How Productive Are the Soils of Central Illinois?
B550 - How Valuable Are the Soils of Central Illinois?

The distribution and general characteristics of the broad soil regions in Illinois are indicated in Illinois mimeograph AG1397 entitled "Principal Soil Association Areas of Illinois."

Publication AG1443 entitled "Illinois Soil Type Descriptions" gives comprehensive information on the characteristics of Illinois soils. This 293-page volume was prepared primarily for agricultural technicians, but it will also be useful to others who wish to become familiar with the characteristics of the soils in Illinois. In addition to the detailed soil-type descriptions, it contains a generalized "Soil Association Map of Illinois." Diagrams of soil profiles and landscapes are included that should make it much easier for persons to become familiar with the relations between associated soil types. Estimated yields of grain crops are given for various soil types under a moderately high level of management. Production indexes for grain crops, forage crops, and timber are also given for the different soils.

There is no charge for single copies of the publications except AG1443. Requests should be limited to those publications which will be immediately useful and should be ordered from Agricultural Information Office, University of Illinois, Urbana, Illinois

COUNTY SOIL REPORTS PUBLISHED

Adams, 24
Bond, 8
Boone, 65
Bureau, 20
Calhoun, 53
Cass, 71
Champaign, 18
Christian, 73
Clay, 1
Clinton, 57
Coles, 44
Cumberland, 69
DeKalb, 23*
DeWitt, 67
Douglas, 43
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Ford, 54*
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Kankakee, 13
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Macon, 45*
Macoupin, 50
Marion, 34
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McLean, 10
Menard, 76
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Morgan, 42
Moultrie, 2
Ogle, 38
Peoria, 19
Piatt, 47
Pike, 11
Putnam, 60
Randolph, 32
Rock Island, 31
Saline, 33
Sangamon, 4
Schuyler, 56
Shelby, 66
St. Clair, 63
Stark, 64
Tazewell, 14
Vermilion, 62*
Wabash, 61
Warren, 70
Washington, 58
Wayne, 49
Whiteside, 40
Will, 35
Winnebago, 12
Woodford, 36

* No longer available for distribution.

Detailed soil maps without soil reports are available for seven additional counties as follows:

Alexander
Crawford
Franklin
Henderson
Monroe
Pulaski
White

R. T. Odell
6/8/53

EFFECT OF SOIL TREATMENT ON CORN ROOTS

Corn roots developed better and yield was higher on a plot receiving soil treatment than on an untreated plot on Cisne silt loam on the soil experiment field at Toledo, Illinois, in 1952.

The treated plot, which had received residue (stover, straws, legumes), lime, phosphate, and potash, produced 75 bushels of corn an acre in a moderately dry season. The nearby untreated plot made only 20 bushels an acre.

Cisne silt loam is a gray claypan soil that is acid and low in fertility. It occurs extensively in southern Illinois and was developed from thin loess under the influence of prairie grass vegetation. The claypan or subsoil begins at a depth of about 16 to 18 inches and extends to about 40 inches.

The general idea has been that crop roots do not penetrate it to any great extent. In this study, however, where enough of the various soil treatments (lime, phosphate, and potash) were applied to the surface soil and legumes were plowed down, corn roots were found to extend to a depth of 60 inches and to be extensively developed in the claypan or subsoil. The zone of most limited root branching was in the very gray, silty subsurface layer just above the claypan. (See illustrations on opposite side.)

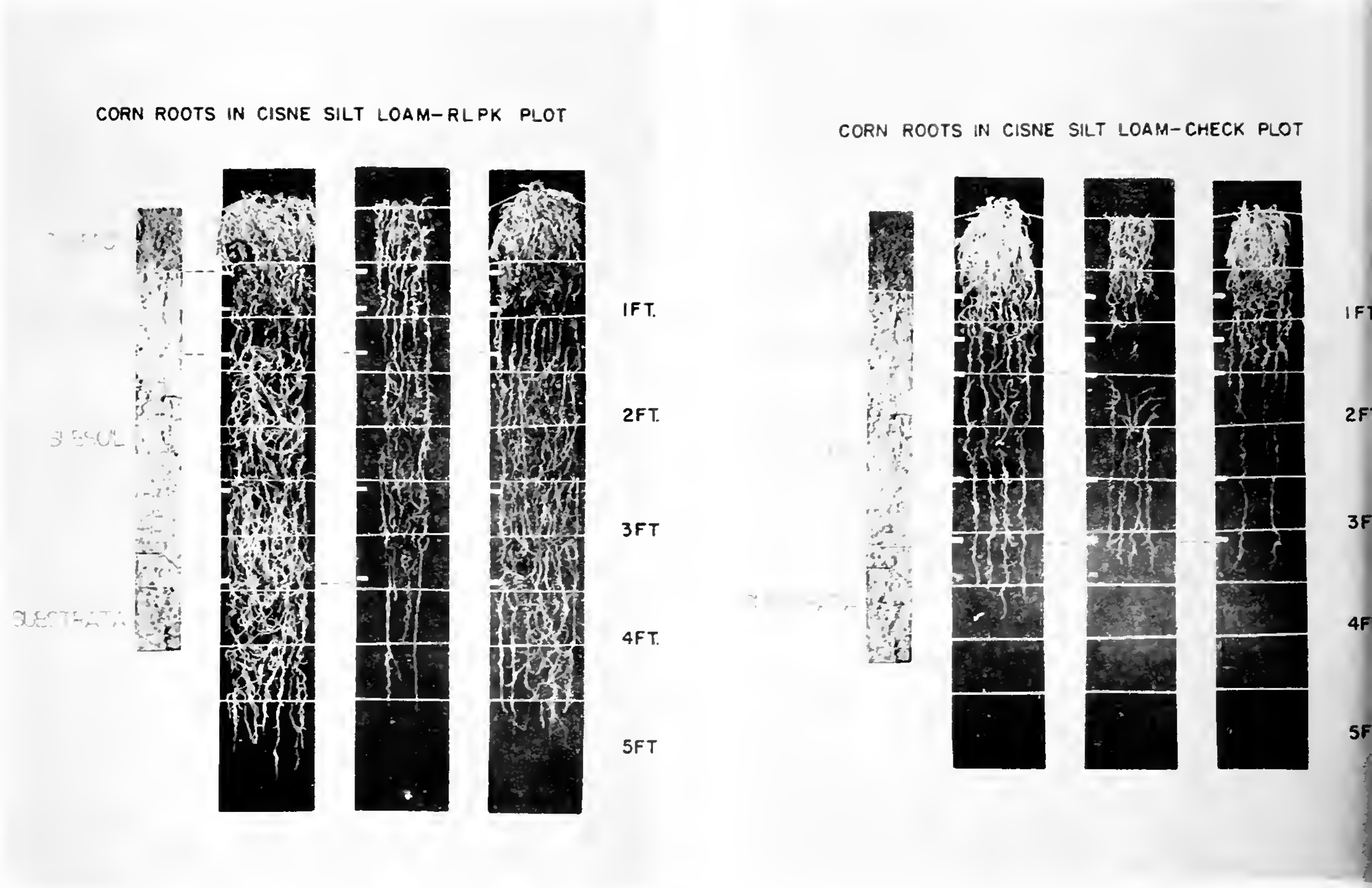
The total weight of corn roots per acre on the fully treated plot was 1.3 tons. The upper 11 inches of the soil contained 78 percent of the roots. Although in the treated plot the amount of available phosphorus below the surface soil was low, the roots probably received some nourishment from the claypan and were able to make good use of the moisture available in that soil horizon.

On the untreated plot corn roots extended to a depth of about 42 inches but were weakly developed in the very gray subsurface layer just about the claypan and in the claypan itself. The total root weight per acre was 0.4 ton, and 82 percent of the roots were in the upper 9 inches of surface soil.

Although these corn root distribution studies cover only one year, it is probable that the results are representative of these that would be obtained on treated and untreated Cisne in seasons having normal to somewhat dry weather.

The results suggest that not only do soil treatments increase yields on such soils as Cisne by furnishing needed plant nutrients, but by furthering root penetration and development in the lower layers of the soil they also make it possible for plants to reach and use moisture at the greater depths.

J. B. Fehrenbacher and H. J. Snider
9-21-53



Corn roots in Cisne silt loam, from a fertilized plot on the left and from an unfertilized check plot on the right. Outside root panels in each set are from 4" x 12" x 72" tray samples taken directly under adjacent 3-stalk hills of corn. Center root panels are from 4" x 6" x 72" tray samples taken halfway between the two hills.

AGRONOMY FACTS

SM-6

MULCH COVER SAVES AGGREGATES IN THE SURFACE SOIL

Numerous experiments have demonstrated that a mulch of crop residues on the surface of soil is very effective in reducing runoff and erosion. Less emphasis has been given to the fact that such a mulch also reduces the destruction of soil aggregates. This is a desirable feature of mulches.

To be productive, a soil must be open and porous enough to drain freely and to admit air readily. To have these properties, most Illinois soils (silt loams and finer) must be aggregated. The individual soil particles must exist in groups or clusters instead of each particle existing alone.

If the soil aggregates are broken down, the soil will be heavy, impermeable, and hard to handle. It will not produce high crop yields, even if there is no lack of plant nutrients. But if a soil is well aggregated, it will drain readily, aeration will be satisfactory, and yields will be high provided sufficient plant nutrients are supplied. Any practice that promotes or protects soil aggregation is therefore desirable from these standpoints.

Soil aggregates can be destroyed in a number of ways. One way that has not received much attention until recent years is by the impact of falling raindrops. Any soil that is left bare is subject to this dispersing action.

Raindrops strike the soil with considerable force, the impact depending largely on the size of the drop. This force is sufficient to break down soil aggregates, disperse or scatter the individual soil particles, and form a compact layer containing little pore space. When dry, this layer forms a crust that on many soils may seriously interfere with the emergence of young seedlings. When moist, the "puddled" layer will not admit water readily and thus causes more runoff.

This damage from falling rain can be largely eliminated by protecting the soil with some kind of cover. The degree of protection will depend on how completely the soil surface is covered. The cover can absorb the impact of the falling raindrops without being damaged, whereas there is a great deal of damage when the bare soil is exposed.

The results given in the following table were obtained on a good corn-belt soil on a 4 percent slope. The samples were taken in the spring after the soil had been exposed to three different conditions over winter. All of the plots were planted to corn in the previous season. On one series wheat straw was spread on the surface at the rate of 2 tons per acre. On the other two series, the corn was planted and cultivated in the usual way.

When the corn was harvested, the stalks on one series were broken down across the slope. On the other series, the stalks were removed at the time the corn was harvested. Each figure in the table is an average of 8 or more single determinations. The samples included about one-half inch of surface soil.

Percentage, by Weight, of Aggregates Larger Than 1/50 Inch in Diameter

Wheat straw	Corn-stalks	Bare soil
18.9	9.2	6.7

These figures show the effectiveness of the straw mulch in protecting the soil aggregates.

R. S. Stauffer
10-5-53

AGRONOMY FACTS

IMPORTANCE OF SOIL CLAYS IN PLANT GROWTH

The clays are composed of the extremely small mineral particles in soils. Because of their fineness, they are by far the most active fraction of the soil. They play an important part in providing a better growing medium for plants. They bind the soil together and thus prevent wind and water erosion. They adsorb water and plant nutrients throughout the year and hold them in a form available for plants to use during the growing season.

Some clays have very high water-holding capacities, while others have intermediate or low capacities. Most Illinois clays have high capacities. Unfortunately, in the absence of soil organic matter, the high-capacity clays hold large amounts of water too tenaciously to make it available to plants. In fact, these clays may actually compete with plants for water.

The high-capacity clays adsorb soil organic matter more tenaciously than water. These stable organic-clay complexes may have higher water-holding capacities than the same clays that are devoid of organic matter. The organic-clay complexes, however, do not hold much water tenaciously enough to prevent plants from taking it away from them. For this reason it can be said that organic matter changes an undesirable property of the clays into a desirable property.

Organic matter also helps to develop good structure in clayey soils and thus increases the rate of water and air movement.

Clays adsorb calcium, magnesium, and potassium by an exchange mechanism through which these elements replace other elements previously adsorbed by a similar mechanism. Growing plants produce hydrogen in the form of carbonic and organic acids. Plants can exchange this hydrogen for calcium, magnesium, potassium, and other basic elements that are adsorbed by clays. In this way growing plants make soils more acid. The farmer reverses this process. He replaces hydrogen on the clays by adding manure, plant residues, lime, and fertilizers.

The weathering of minerals in soils furnishes some of the basic elements that saturate the clays. These clay-adsorbed elements are not released by water unless the water contains similar dissolved elements to exchange for those already on the clay. The clays therefore serve as a "trading and storage center" where plants can select the nutrient elements they need. If this were not so, we would need to anticipate and supply the balanced nutrients in the form of fertilizers as fast as these elements were removed by leaching and crop removal. If there were absolutely no clay or organic matter in a soil, it would certainly need to be fertilized after every heavy rain in order to support plant growth.

Soils that are high in clay and low in organic matter are not favorable for plant growth because they do not let water and air move freely through their profiles and because most of their adsorbed water is not available for plant growth. But soils that are high in clay and high in organic matter, when properly limed and fertilized, do provide a favorable medium for plant growth because they hold and conserve large amounts of water and nutrient elements in a readily available form.

J. E. Gieseking
10-12-53

SOIL MANAGEMENT & CONSERVATION

AGRONOMY FACTS

SM-8

SLICK SPOTS

The so-called slick spots of south-central and southern Illinois are light-colored silt loam soils that are very low in productivity. They have thin surface and subsurface horizons and very slowly permeable subsoils that are usually high in replaceable and total sodium. Those slick spots that have well developed silt loam surface and subsurface horizons 10 to 16 inches thick (total depth to top of subsoil or claypan), and subsoils with a high pH and high sodium content, have been given the name of Huey silt loam.

Occurrence. The slicks occur as spots of variable size with many soils but are most commonly associated with Cisne, Cowden, and Herrick silt loams. They are largest in the Cisne and Cowden. In some places, particularly the western half of southern Illinois, they may occupy over 50 percent of Cowden and Cisne areas.

In general, slick spots are confined to that part of Illinois having soil parent materials consisting of less than 100 inches of loess overleached Illinoian glacial till. Most of them have developed under grass, although occasionally they have developed under forest vegetation.

They are frequently found along or near the head of shallow drainageways. They may also occur on or near the base of steep slopes, on "dead" flats, or sometimes in depressions. In general, they have developed under poor drainage conditions and usually have mottled gray subsoils. However, occasionally one may have a brownish-colored subsoil similar to that of soils developed under moderately well-drained conditions.

Characteristics. Slick spots have lighter colored surfaces than adjacent nonslick grassland soils, they are lower in organic matter content, and they have shallower depths to the top of the claypan subsoil. The subsoil often contains less clay than adjacent soils, but the sodium content and pH are usually higher. Occasionally spots are found that have all of the physical appearances of slicks but that differ chemically by being acid throughout their profiles.

Slick spots tend to be higher in sodium content in the layers below the surface soil, but there is usually little difference between slick and nonslick soils in pH or sodium content in the surface layers. However, in slicks that occur at the base of slopes, where seepage is pronounced, white, powdery, alkaline salts may accumulate on the surface during dry periods. The most common salt appears to be sodium sulphate. Figure 1 shows the variation with depth of average content of replaceable sodium for four Cowden profiles, five Cisne profiles, and five slick spot profiles.

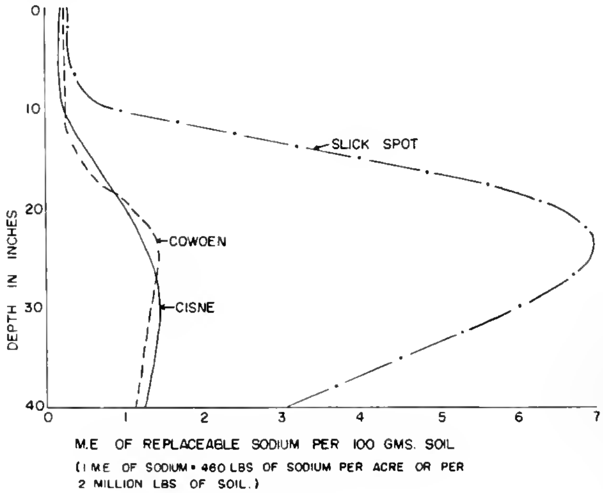


Figure 1

Besides having lighter colored surface horizons and shallower depths to the top of the subsoil, many slicks have in their subsoils gray concretions of calcium carbonate varying in shape and ranging from 1/8 to 1 inch in diameter. The presence of calcium carbonate can be checked by dropping dilute hydrochloric acid on subsoil samples and noting whether bubbling occurs. The pH of the subsoils that do not effervesce with acid can be checked with field pH test kits, which are much quicker and easier to use than present field tests for replaceable sodium. If the pH of the subsoil of a suspected spot is above 7.0 at a depth as shallow as 24 inches, the area is probably slick.

Figure 2 on the back of this page shows the relation between pH and replaceable sodium content of the subsoil of some slick and nonslick samples. While there was some variation, the samples having a pH greater than about 7.0 and a replaceable sodium content of about 3 or more milliequivalents were slick.

Figure 3, also on the back page, shows the relation between average replaceable sodium content of the subsoil of slick and nonslick soils and average depth to subsoil. As depth to subsoil (or thickness of surface and subsurface layer) decreases, average replaceable sodium content increases.

Because of the high sodium content, the physical condition of the subsoil is very poor. The sodium keeps the clay dispersed, and as a result permeability to water is very slow. When dry, the subsoil

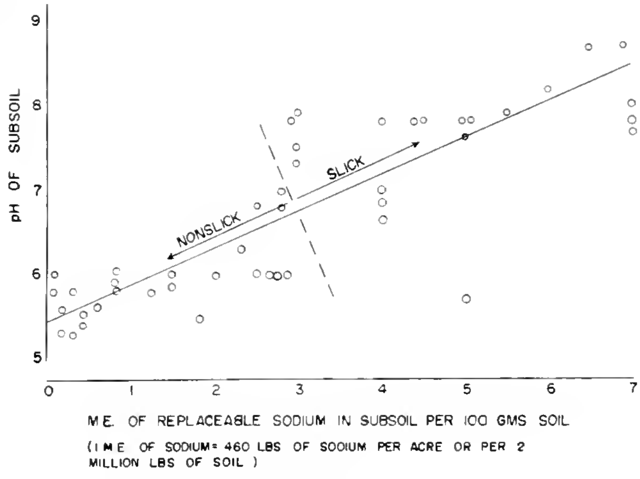


Figure 2

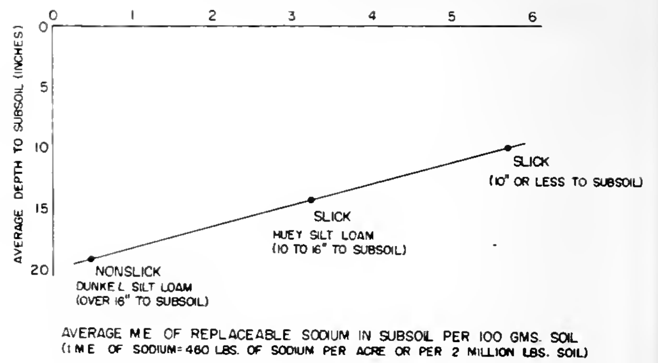


Figure 3

is quite hard and slow to wet up following rains; and when wet, it is very slow to dry out. Its ability to supply moisture to crops is low, and this in part accounts for the very low productivity of these spots.

The other major factor, besides the high sodium content of the subsoil, contributing to low productivity is the acid, low nitrogen, phosphorus, and potassium content of the surface soil. The degree of toxicity of plants to various amounts of sodium in these soils has not been determined. From the available data it appears that a soil having over about 3 m.e. of replaceable sodium per 100 grams of subsoil or a soil in which sodium takes up over 10 to 15 percent of the capacity of the subsoil to hold bases should be classified as slick. Such a soil will have a lower productivity, because of more adverse physical and chemical properties, than adjacent nonslick soils.

Origin. The origin of slick spots has been variously attributed to the accumulation of bases under an arid or semiarid climate, to interruption of leaching of a shallow loess by an underlying highly impervious Illinoian glacial till, to interruption of drainage by a high water table, and to lateral movement of drainage water that is relatively high in sodium and subsequent accumulation of the sodium because of evaporation of the water. Seepage or hydrostatic pressure or capillary rise may account for movement of the water to points at the surface of the soil where evaporation would follow. The source of the sodium has been attributed to weathering of primary minerals in the loess.

The idea that slick spots are relics of a formerly arid climate is questionable. It does not explain the influence of parent materials on their occurrence. The other ideas presented above all involve the accumulation of sodium under the present climate by lateral movement of ground water or by interruption of leaching. That the movement of ground water is involved in the accumulation of the sodium and the formation of the slick spots is a certainty, but the exact mechanism and processes involved are not fully known. Mineralogical and chemical studies in progress to determine the replaceable and total sodium, possibly the source of the sodium, and the type of clay minerals present may help to explain further the genesis or origin of these soils.

Use and management. Soil treatment to improve the productivity of slick spots often gives disappointing results because it does not remedy the poor physical properties nor the high sodium content of the subsoil. Some improvement can be made on most of these spots, particularly where the depth to the subsoil is more than 12 inches. If the subsoil is very shallow or has been exposed by erosion, little can be accomplished with soil treatment.

One of the first steps in the management of these soils is to provide adequate drainage. Tile will not draw satisfactorily, but sometimes an open inlet into a tile line can be used to remove excess surface water. Ordinarily an open ditch is the cheapest and most practical means of drainage. If suitable drainage can be provided, the surface soil should be treated according to needs as determined by soil tests.

In addition to lime, phosphate, and potassium, the need for nitrogen on these spots is generally great. If the spots are small and not too numerous, they must ordinarily be farmed with surrounding soils. However, if they are large enough to be farmed separately, they can often be used more successfully for winter small grains or pasture than for summer crops, such as corn and soybeans.

Use of gypsum or some other chemical agent to replace the sodium in the slick spots might warrant further investigation. However, one of the major difficulties of such a method is to get adequate underdrainage for flushing or washing out the sodium. A few farmers have tried burying such materials as corncobs in slick spots to improve their permeability to water, but the benefits of such treatments are generally temporary. Others who have only a few small slick spots have hauled in dirt removed from highway shoulders and ditches. Building up the thickness of more permeable material above the subsoil will reduce the adverse effects of this horizon on crops.

One good thing can be said for slick spots. Where they are suitably located, as in a drainageway, they make excellent pond sites. Their high sodium content keeps the clay dispersed or puddled and consequently very slowly permeable to seepage of water.

J. B. Fehrenbacher
11-23-53

AGRONOMY FACTS

SM-9

HOW MUCH WATER AND PLANT NUTRIENTS ARE LOST BY RUNOFF AND EROSION FROM GENTLY SLOPING, PERMEABLE, DARK-COLORED SOILS IN ILLINOIS?

These results are based on data obtained on the Agronomy farm at the Illinois Agricultural Experiment Station, Urbana, Illinois. The soil is Flanagan silt loam, a highly productive, permeable soil on a 2 percent slope. The land had been owned by the Illinois Agricultural Experiment Station for more than 30 years before the project was started. Lime and fertilizers had been applied and a rotation of corn, oats, clover, and wheat had been followed. The soil was in good condition and runoff and erosion were not a serious problem.

From 1941, when this project was started, until 1944 inclusive, a rotation of corn, oats, with a sweet clover catch crop, was followed. Since 1945 the rotation has been corn and soybeans with no catch crop. Since 1947 heavy applications of fertilizers have been made.

The following tables give the amount of runoff and the loss of some plant nutrients in the soil removed by erosion.

Average Annual Runoff in Inches

	Up and down1/			Contoured2/		
	Highest	Lowest	Av.	Highest	Lowest	Av.
	in.	in.	in.	in.	in.	in.
Corn (12 yr.)	4.66	1.01	2.30	3.23	0.02	1.32
Soybeans (8 yr.)	4.88	1.18	2.19	1.99	0.01	0.75
Oats (4 yr.)	2.79	0.77	1.80	2.28	0.88	1.49

1/ Farmed up and down the slope
2/ Farmed on the contour

Average Annual Losses of Organic Matter, Nitrogen, and Phosphorus in Pounds per Acre

Organic matter		Nitrogen		Phosphorus	
Up and down1/	Contoured2/	Up and down1/	Contoured2/	Up and down1/	Contoured2/
lb./A.	lb./A.	lb./A.	lb./A.	lb./A.	lb./A.
306	112	15.2	5.8	3.8	1.4

1/ Farmed up and down the slope
2/ Farmed on the contour

R. S. Stauffer
Nov. 2, 1953

MANAGEMENT PRACTICES AND CROPS ADAPTED TO SANDY SOILS

Proper management of sandy soils requires a thorough knowledge of the physical and chemical properties of the different soils in each field or crop area. The reason is that soils vary in their capacity to absorb and retain water and to furnish plant nutrients and store them for future use, as well as in many other factors that are important to satisfactory plant growth and crop yield.

Some sandy soils have subsoils in the upper 3-foot section that contain large amounts of clay, some have moderate clay accumulation, and others have little or no clay. Milroy sandy loam is an example of a soil whose subsoil is too heavy and impermeable for favorable water movement and root penetration. Ridgeville fine sandy loam, which has a moderate amount of clay in the subsoil and other favorable features, represents the best of the sandy soils. Plainfield sand is an example of a soil with no clayey subsoil to a depth of 3 or 4 feet.

Ridgeville soils, even when untreated, often produce moderately good crops of corn and soybeans, especially in years of favorable weather. Without full treatment, however, Milroy and Plainfield seldom or never produce satisfactory yields of these two crops.

Similarly those sandy soils that have a large proportion of fine or very fine sand, like Onarga fine sandy loam, are better storehouses for water and plant nutrients than those made up mostly of medium or coarse sand, like Sumner sandy loam. Also, soils having dark-colored surface layers that are 8 to 10 inches or more thick, such as Disco fine sandy loam and Hagener loamy fine sand, contain larger amounts of organic matter and thus more nitrogen and other plant nutrients than soils in which the dark surface is thin or absent, such as Alvin sandy loam, Roby fine sandy loam, etc.

Furthermore, sandy soils that have a moderate to high proportion of organic matter or of clay particles are less easily moved by the wind and are therefore less hazardous to use for growing clean-tilled crops than are the excessively sandy soils.

Most sandy soils are medium to strongly acid and usually need some limestone to produce the best growth of clovers and alfalfa. However, sandy soils have a lower capacity to retain bases than have the finer textured silt loam and clay loam soils. This means that less limestone is needed to neutralize the indicated acidity, although it also means that limestone should be added more often. In the excessively sandy types, the potassium thiocyanate test for acidity often requires the addition of iron to show the proper test color.

Phosphate and potash fertilizers should be applied according to test, but primarily to meet the needs of the immediate crop, since sandy soils do not hold large amounts of these materials for any length of time. Nitrogen is also an important plant nutrient that is usually deficient, particularly in the lighter colored and excessively sandy soils.

Large amounts of organic matter--barnyard manure, green manure, crop residues, or other organic materials--are valuable

additions to sandy soils not only for supplying plant nutrients, but also for increasing their water- and base-holding capacity and their stability against wind movement.

There are a number of special practices that may be used to help reduce wind movement of sandy soils and thus tend to increase crop yields. Among them are keeping the soil surface covered by growing vegetation or by crop residues as much as possible; leaving the plowed surface rough; plowing in such a way as to leave some plant residues on the surface; covering the soil surface with manure; plowing ridges and furrows at right angles to prevailing west winds so far as possible; planting clean-tilled crops in strips with small grains and forage crops at right angles to prevailing winds; contouring strip crops where the slope warrants; and using shelter belts.

As has been pointed out, many sandy soils, when untreated, are not particularly well suited to growing corn and soybeans. Returns from these crops do not consistently repay the cost of production. The data given below, however, indicate that applying adequate amounts of manure, with limestone, phosphorus, potassium, and nitrogen as needed, will greatly increase yields of these two important crops, perhaps even to the point where they will return a moderate profit.

Other crops that are better suited to sandy soils are such early-maturing crops as rye and wheat, deep-rooting crops like alfalfa, and probably some special crops like melons and cowpeas.

Oquawka Soil Experiment Field*
Average Annual Acre Yields of Corn, Soybeans,
Wheat and Alfalfa, 1915-1952, Inclusive

Treatment	Corn 38 crops	Increase for N, 4 crops**	Soybeans 38 crops	Wheat 37 crops	Alfalfa-hay 35 crops
	bu.	bu.	bu.	bu.	tons
Manure	37	..	12	13	1.0
Manure-limestone	47	..	16	19	2.4
Manure-limestone-rock phosphate	47	..	16	20	2.4
No treatment	27	20	8	10	.7
Residues-limestone	43	19	13	16	2.1
Residues-limestone-rock phosphate	43	12	13	16	2.0
Residues-limestone-rock phosphate-potash	47	21	17	17	2.6

*Located primarily on Oquawka sand and Hagener loamy sand.
**A side-dressing of 60 pounds per acre of nitrogen was applied 1949-1952, inclusive.

H. L. Wascher
11-30-53

WHAT DO WE KNOW ABOUT DEEP TILLAGE?

A great deal has been said and written about deep tillage. Its benefits have been described in glowing terms in popular agricultural journals and magazines and in literature published by commercial companies. However, scientific agricultural literature, based on carefully conducted experiments, does not bear out these extravagant claims. There may be exceptions like plowing an area in California 5 feet deep to turn under undesirable sandy, gravelly material that had washed onto the surface of very valuable land. Sometime a method to make compact, impervious soils open and porous by mechanical means may be found. To the present, however, for the usual conditions encountered in farming there is a very definite lack of acceptable data to show that deep tillage greatly benefits the soil long enough to pay for its cost.

In this discussion deep tillage means 10 inches or more in depth and includes any method of penetrating the soil to that depth. Some results on deep tillage are given in the following tables, with descriptions of the soils and the conditions under which the results were secured.

Illinois Results - Corn Yields, Bushels per Acre
(Ill. Agr. Exp. Sta. Bul. 258. 1925)

Flanagan silt loam - Av. 6 yr.			Cisne silt loam - Av. 13 yr.			
			Depth plowed			
	Yield		No fertilizer		RLPK[1]	
Depth plowed	1st yr. corn	2nd yr. corn	Ordinary[2] plowing	Sub-[3] soiled	Ordinary[2] plowing	Sub-soiled
....	....	....	16.1	15.6	39.6	36.4
7	65.9	62.3	....	....	....	....
12 - 14	65.7	63.6	....	....	....	....

Rotation on Flanagan silt loam - corn, corn, oats, sweet clover.
Rotation on Cisne silt loam - corn, soybeans, wheat, red clover.

1/ RLPK means residues, lime, phosphorus, and potassium had been applied to the surface of this area.
2/ About 7 inches deep.
3/ About 14 inches deep.

Flanagan silt loam is a dark-colored corn-belt soil occurring extensively in east-central Illinois.

Cisne silt loam is a gray prairie soil with a relatively impermeable claypan subsoil.

The author of the bulletin concluded, "That such methods (deep tillage) are not superior to ordinary or medium depth plowing has been indicated by subsoiling experiments...."

(Continued on other side)

Tennessee Results - Yields of Corn in Bushels per Acre
(Tenn. Agr. Exp. Sta. Bul. 191. 1944)

	Depth of plowing		
	6 inches	10 inches	6 inches and subsoiled 6 inches
Olivier silt loam1/	48.2	49.7	49.7
Huntington fine sandy loam2/	73.9	74.5	....
Cumberland loam3/	47.5	47.4	....
Baxter silt loam4/	52.4	53.0	....

1/ 14 years' results; 2/ 3 years' results; 3/ 2 years' results; 4/ 4 years' results

Olivier silt loam, a residual soil, grayish-yellow surface, yellow silty clay loam upper subsoil, heavy but friable Huntington fine sandy loam bottomland soil.

Cumberland loam, grayish-yellow surface, heavy red, compact subsoil.

Baxter silt loam, grayish-yellow surface, reddish subsoil, from cherty limestone and dolomitic limestone.

The author of this bulletin concluded that "Neither subsoiling or extra-deep disk plowing proved profitable."

Missouri Results - Grain Yields, Bushels per Acre

4-year av. 1943-1946	Plowed normal	Shattered subsoil	Shattered subsoil plus1/ lime and fert. in subsoil
Corn	24.5	29.7	32.0
Oats	31.9	30.9	32.9
Barley	20.3	16.7	20.1

1/ Two tons limestone and 200 pounds 8-20-10 fertilizer in shattered subsoil.

Putnam silt loam, slowly permeable soil with claypan subsoil. Two rotations: corn, barley, sweet clover as green manure and corn, oats, lespedeza as green manure. To shatter subsoil, a regular 18-inch tractor plow was used to a depth of 10 or 12 inches, followed by a 12-inch walking plow in first furrow. Total depth ranged from 16 to 20 inches.

I have been unable to secure more recent results from this project, but I understand that the effects of the subsoil shattering were rapidly disappearing even where the limestone and fertilizer had been added to the subsoil. The results given in the table, which were secured at the beginning of the experiment, are more favorable to the treatments than later results would be. Even these results are not a strong recommendation for subsoil shattering and fertilizing. It requires an increased yield of more than 7.5 bushels of corn to pay for the treatment, especially if its effects last only four or five years.

An article published recently (Soil Sci., Apr. 1953) gives some results of subsoil shattering in the sugar cane soils of Puerto Rico. The authors state that shattering the subsoil without adding

fertilizers generally reduced yields. Where lime and fertilizers were added to the shattered subsoil, yields were increased by about 14 percent. These soils are fine textured and have grown sugar cane for years. They are usually in very poor condition and should benefit from subsoiling more than most soils. However, the increase in yield of sugar is not phenomenal, and there is no indication how long the results may last.

Many other references on subsoiling could be cited, but the conclusions would still be the same as the one reached in 1918 (Jour. Agr. Res. 14:481-521) and quoted in a recent book (Soil Conditions and Plant Growth, 1952): "Yields cannot be increased nor the effects of drought mitigated by tillage below depth of ordinary plowing. The quite general popular belief in the efficiency of deep tillage as a means of overcoming drought or of increasing yields has little foundation of fact, but is based on misconceptions and lack of knowledge of the form and extent of the root system of plants and of the behavior and movement of water in the soil."

R. S. Stauffer
12-28-53

AGRONOMY FACTS

THE NATURE OF SOIL ACIDITY

One cannot discuss soil acidity without talking about the available soil forms of three very important plant foods, calcium, magnesium, and potassium.

Soil reaction or acidity is caused by positively charged hydrogen ions which are attached to the negatively charged surfaces of the billions of small clay and humus particles in the soil. But positively charged calcium, magnesium, and potassium ions are also attached to these negatively charged surfaces.

Every negatively charged spot on the clay and humus must be occupied by a positively charged atom. If there are no bases like calcium, magnesium, and potassium to satisfy these negatively charged spots, then hydrogen, the acid ion, must be there and must satisfy the negative charge.

So the acidity of a soil depends on the balance or proportion between the acid ions and the basic ions on the clay-humus. If 80 percent of the clay-humus particles are covered with bases, then the soil will be in the sweet range. If only 25 percent of the clay-humus is base covered, then 75 percent will be acid ions and the soil will be highly acid.

When a soil is too acid, liming material is applied to sweeten it. If this material is a dolomitic limestone, as it often is, then it supplies both calcium and magnesium. As the small limestone particles slowly dissolve, the calcium and magnesium ions displace the acid ions from the clay-humus surfaces; that is, they exchange places. The calcium and magnesium ions are then on the clay-humus, and the hydrogen ions are in the soil water as carbonic acid, a harmless acid normally present in all soils.

As this process continues, the soil around each little limestone particle becomes charged with calcium and magnesium and the number of acid hydrogen ions decreases.

Although plant roots feed very efficiently from these bases, leaching rains can remove them only slowly. As calcium and magnesium are removed, the hydrogen ions again take the place left vacant by their removal. With time these small removals mount up, and the soil becomes acid enough to make reliming necessary.

In order to be sweet, a soil need not contain any limestone. Limestone itself is not the cause of sweetness. It is a high proportion of calcium and magnesium, principally calcium, on the clay-humus surfaces that causes the soil to have a favorable reaction (as measured by its pH). It can contain unused limestone and still be acid if the limestone has not had either the time or the opportunity to react with the soil.

The acid soil particles cannot move to the limestone particles or vice versa. A large particle of limestone will react with the nearby soil and then practically stop dissolving because it has neutralized all of the nearby acid. So it is important for limestone to be fine.

(The agricultural limestone used in Illinois is a compromise between fineness and price. A grind containing both fine and some coarse particles is less expensive in the long run than all finely ground material. Enough lime should be applied to permit the fine material to neutralize sufficient soil, leaving the coarse to keep it sweet as plants and rains slowly remove the bases.)

Since the limestone particles cannot move around to where they are needed, they must be put where they are needed. If they are broadcast on the surface and left there, they can sweeten only a quarter of an inch or so of the surface soil and the rest will remain acid no matter how much lime is applied. If they are broadcast and then plowed under, without first being mixed with the soil, they can also sweeten only a very little soil. The surface will still be acid and clovers will not nodulate.

But if they are broadcast and mixed well with the soil, then all through the soil will be sweet areas which can serve as centers for the legume bacteria to nodulate the legume roots. The principle to use is: Put the limestone where the roots will be. Time and opportunity for reaction will produce a properly sweetened soil, but really coarse limestone takes too much time to react, and poor mixing gives well-ground limestone no opportunity to react.

The best way to apply limestone is to broadcast and mix it well by disking, harrowing, etc., before sowing legumes. But do not plow! Plowing brings up acid soil and puts most of the sweet soil down below. If the land is plowed after liming, it must be plowed again before legumes are planted in order to bring the sweet soil back to the top.

A properly limed soil is not necessarily one that is sweet throughout. Even with good mixing, both sweet and acid areas will remain. But with continued cultivation the sweet and acid soil will gradually merge. A sample from a soil limed during the past five years or so may not give a sweet reaction because the test is made to determine the acidity and the reaction will be with the acid spots. Nevertheless, the clover roots find the sweet spots and are nodulated.

The pH scale is merely a numerical method of expressing the balance between acid and base in terms of the hydrogen ion concentration. A pH of 7 is neutral, a pH of around 6.3 is sweet, or adequate for sweet clover and alfalfa; a pH of around 5.4 is too acid for most clovers but not very harmful for the more acid-tolerant plants like soybeans, corn, and wheat; and a pH of 4.5 to 4.1 is highly acid and harmful to any but acid-loving plants.

The exact pH range that any one plant will tolerate also depends on other unknown factors. Sometimes clovers are found growing where the pH is supposedly too low for their successful growth. Liming recommendations attempt to adjust the pH to a range where all legumes can always be successfully grown.

Roger H. Bray
1/12/53

THE NATURE OF AVAILABLE POTASSIUM IN SOILS

The clay minerals and the soil humus possess the property of holding on their surfaces the ions of such nutrients as potassium, magnesium, and calcium as well as the acid hydrogen ions. These surface-held ions, which are the available forms of potassium, calcium, and magnesium, are called exchangeable ions. The clay minerals and humus are called base-exchange materials.

The exchangeable ions are held on the clay-humus surfaces by electrical bonds. The clay-humus is negatively charged (-), and the exchangeable ions are positively charged (+). They attract each other, and the positive ions cling to the negative clay-humus surfaces. But if a salt or acid is present in the surrounding water and ionizes into + and - ions, the + ions can displace (exchange with) the + ions on the clay-humus and force the exchangeable ions into the soil water.

For example, when small amounts of nitric, sulphuric, and carbonic acids are formed in the soil by decomposition of soil organic matter, the hydrogen (acid) ion displaces exchangeable Ca, Mg, and K ions, which go into the soil water as companions for the sulphate, nitrate, and bicarbonate ions. In a sweet soil, nitric acid is changed into calcium, magnesium, and potassium nitrates, leaving only traces of the acid.

The proportion of any one base (positive ion) in solution depends on the composition of the exchangeable bases held on the base-exchange surfaces (the clay mineral and humus surfaces). Usually calcium is so abundant that the salts are mainly calcium salts. A common proportion in our brown silt loam soils would be 60 percent Ca, 30 percent Mg, 3 percent K and 7 percent H.

Plant roots feed on this mixture of salts and acids in the soil solution. They do not, however, feed on them in this same proportion, but take out relatively more potassium. As the plant roots remove the potassium, more exchangeable potassium is displaced in order to readjust the composition of the soil water.

Thus, through this equilibrium, the exchangeable potassium is the source of K for plant feeding, and for this reason it is called available potassium. The exchangeable calcium and magnesium are also the principal available forms of these nutrients in soils of humid regions.

In Illinois soils containing much illite (a clay mineral containing potassium), the surface-exchangeable potassium is also in equilibrium with a part of the potassium <u>within</u> the clay particle. So when potassium is removed by plant feeding, more of it is slowly released to the surface. When potassium is added to the surface soil, part of it goes slowly into the interior and is no longer immediately exchangeable.

We call this potassium in the interior the storehouse form, because excess K goes into it. But as plants remove too much of the surface potassium, it is slowly renewed from the storehouse form. This equilibrium prevents leaching of excess potassium and regulates the potassium at a level that reflects the ability of the storehouse to renew it once equilibrium is established.

For example, when the equivalent of 100 pounds of K per acre is added to a soil already containing 150 pounds and is allowed to stand for a long time without cropping or any chance of leaching, the

exchangeable potassium at first will be the sum of that present plus what is added, or 250 pounds. In time, however, it will go down to 200 pounds or less. That is, part will go into the storehouse, and the amount which would be recovered in a soil test would be less than the sum of the amount already there and the amount added, even though no cropping or leaching took place.

On the other hand, if a soil containing 150 pounds of K per acre is cropped and the crop removes 50 pounds, the exchangeable K at the beginning of the next season will not be 100 pounds, but may be as much as 140 or 145 pounds because of the release from the storehouse.

So a soil test value gives the results of the equilibrium between the storehouse and the available potassium, provided enough time has elapsed to produce the equilibrium. For this reason it is good practice to avoid taking samples from areas where potassium has been very recently applied or from the dense part of the root system of a growing plant. The equilibrium value is the one that should be measured.

When potash salts are added, they react with the first soil clay they contact. For example, if 100 pounds of muriate of potash is added to the surface soil and not mixed in, over 80 percent of the K+ will be adsorbed in the top quarter inch. When 400 pounds are added, over 50 percent will be adsorbed in the first quarter inch.

The final result of adding a fertilizer such as potassium chloride is that the added potassium is now held safe from immediate leaching on or in the soil clay, while the calcium joins the chloride ion in the soil water and both are eventually leached away, carrying with them only traces of potassium and some magnesium.

But because the potassium reacts with the first clay soil it contacts, it must be put where it is wanted. If broadcast on the surface, it must be disked into the soil in order to be effectively used. If drilled, it must be drilled near the seeds and yet not near enough to cause burning, especially in soybeans. If used for top dressing, the potassium will be only partially effective because it will attach itself to the surface clay, which often dries out and then cannot be used by the plant.

To measure the amount of exchangeable (available) potassium in a soil, all one has to do is first thoroughly air-dry the soil and then add enough of another salt to cause the positive ions of the salt to displace all of the exchangeable potassium. After filtering, the exchangeable potassium is in the filtrate and can then be measured. But if the soil is not thoroughly air-dried (for over 10 days after it is dry enough to screen), the salt cannot replace all of the exchangeable potassium.

Because of the storehouse phenomena, the same soil test value for available K may have different long-range interpretations.

On the dark-colored soils where the storehouse is still fairly well filled, a 180-pound test, for example, is an adequate value for most crops and, because of renewal from the storehouse, will not decrease rapidly.

But a 180-pound test on a light-colored clay pan soil in southern Illinois does not mean the same thing. These untreated soils almost always have very little K in the storehouse. A 180-pound value may mean that potash has recently been supplied and little of it has yet gone into the storehouse. Or it may mean that the continuous use of K has built up both the storehouse supply and the exchangeable potassium supply.

This means that the 180-pound test value can be interpreted in three different ways:

1. On a dark-colored silt or clay loam soil in central and northern Illinois, where the storehouse is large and fairly well filled, it means that K is not now deficient, will not become seriously

deficient over the next few years, need not be returned in an amount equal to that removed in crops, and is required in only a small amount in drilled or hill-dropped fertilizers for balance and starter effect.

2. On the highly weathered, originally highly acid and potash-deficient soils of southern Illinois (for example, the light-colored clay-pan soils) that have had previous treatment with K extending over 10 to 15 years, this test value means that the storehouse has been at least partly renewed and that only maintenance amounts should be used to keep the level adequate.

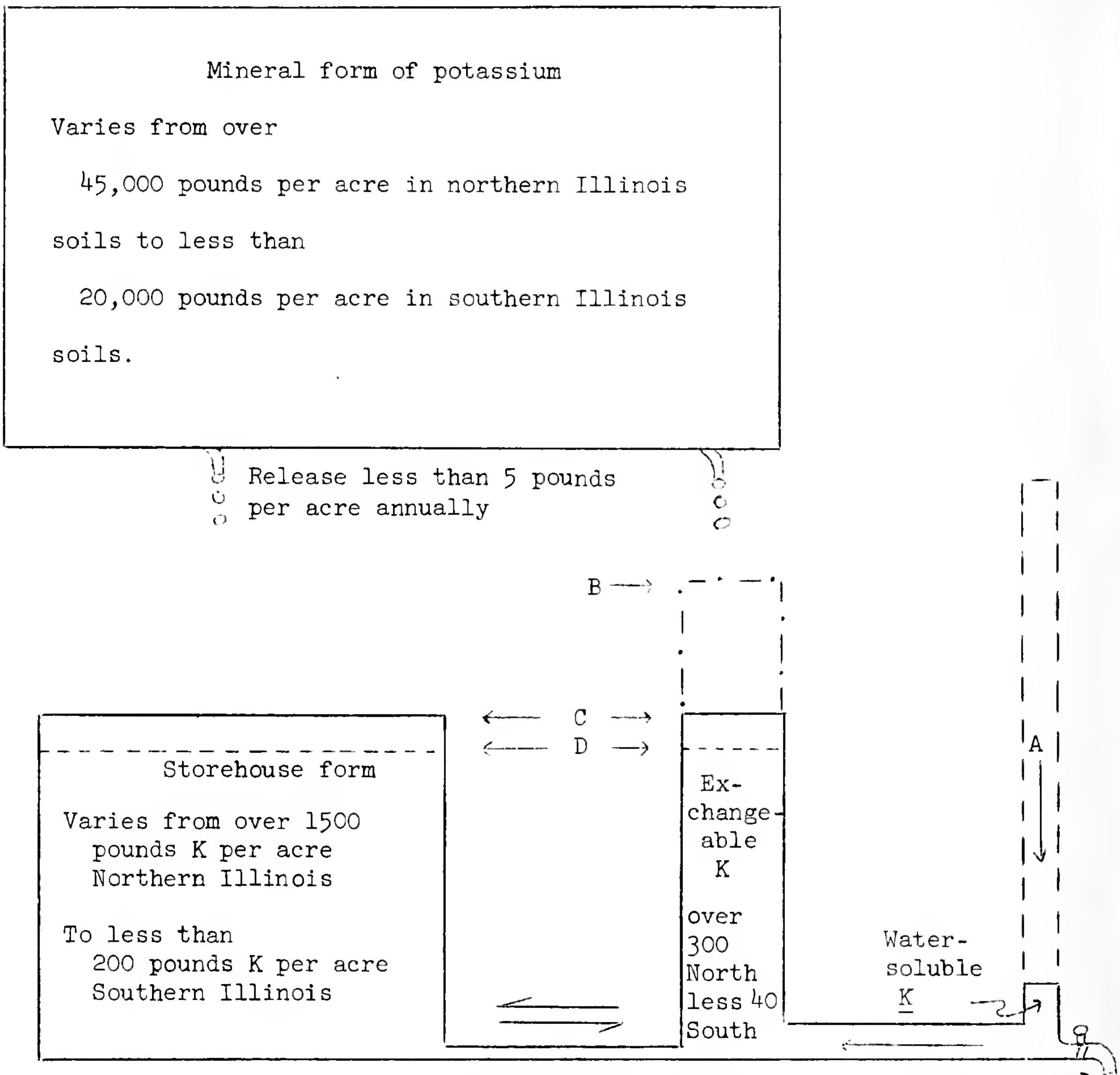
3. On the same kind of soils as are described in (2) above, but which have had only one or two recent treatments with potash, then this test value should be regarded as showing sufficient K for that year only. Any recommendations for future treatments should be made on the basis that the soil is deficient in potash.

It is therefore obvious that for soils that are naturally deficient in potassium a history of previous treatments is needed as a guide in interpreting soil tests.

Because the exchangeable potassium is renewed only slowly after plant roots remove it, the highest soil tests will be obtained in the spring. Partial renewal of the potassium used by previous crops will then have occurred. It is however, impossible to give correlations for soil tests for every month of the year and for every cropping history. The correlation used in the soil testing laboratory to interpret the soil test value is for the average situation rather than for either extreme, and it is adequate for samples taken any time of year.

Roger H. Bray
1/12/53

FORMS OF POTASSIUM IN ILLINOIS SOILS
AND THEIR EQUILIBRIUMS



A = Added K. Most potash fertilizers are water soluble. When added to the soil, they dissolve in the soil water.

B = Immediate equilibrium level - The dissolved fertilizer reacts with the soil colloid and all of the added K becomes exchangeable, giving a big increase in total exchangeable K in the soil.

C = Final equilibrium levels - With time exchangeable K reaches an equilibrium with the storehouse form. Much of the added K goes to this form if the soil is low in the storehouse form.

D = Original equilibrium levels in the soil.

AGRONOMY FACTS

THE NATURE OF AVAILABLE PHOSPHORUS IN SOILS

The available soil forms of phosphorus are the least understood of the three principal major nutrients. It is certain that two or more forms are present in most soils, and they can be discussed under two headings: (a) the adsorbed forms and (b) the acid-soluble forms.

The adsorbed forms: When soluble phosphate is released through the decomposition of soil humus and plant organic matter or is added as a soluble phosphate like superphosphate, a good share of it is adsorbed by the colloidal clay minerals in the soil, and perhaps by the hydrous oxides of iron and aluminum or concretionary material. This adsorption greatly reduces its solubility and hence its mobility in the soil. It will not leach out and yet plants can feed on it.

The larger the amount of adsorbed phosphate in any one spot, the higher its solubility and the more readily plant roots can feed on it. Therefore, in practice, it is advantageous to add soluble forms of phosphates to a soil in such a way that they will not be thoroughly (evenly) mixed with the whole soil. Broadcasting and disking, for example, mix the phosphates unevenly enough to leave small patches or areas that are very high in adsorbed phosphorus. That means that the phosphate adsorbed in these areas will have relatively good solubility and hence higher availability for root feeding. The soluble phosphates are adsorbed even less strongly when put into the row or hill than when broadcast.

Plant roots develop more extensively within these patches and feed much more effectively than if the solubility and positional availability were further reduced by thorough mixing. This unused phosphate, however, gradually mixes with more and more soil as repeated plowing and cultivating stir the soil. Although it will still be available, its availability will finally be reduced to that of the more evenly distributed forms.

The distribution of the available form of a nutrient in the soil is called its fertility pattern. An uneven or irregular fertility pattern can increase the availability (both chemical and positional) of such available soil forms as adsorbed and acid-soluble phosphate (rock phosphate is an exception) and exchangeable potassium.

The acid-soluble forms in turn consist of two types, the naturally occurring acid-soluble forms and rock phosphate. The natural acid-soluble forms, so-called because dilute mineral acids can dissolve them, would probably be better called the calcium forms. Mono-calcium phosphate (the form in superphosphate) is a soluble form. When added to the soil, the part that is not adsorbed (see above) is apparently changed to less soluble forms that are higher in calcium. In sweet soils that are high in exchangeable (available) calcium, the water solubility of these higher calcium forms is still further reduced.

Sweet or near-neutral soils contain a relatively higher proportion of the acid-soluble (higher calcium) forms and relatively less of the adsorbed forms than do acid soils. Liming a soil changes much of the adsorbed phosphorus into the easily acid-soluble forms. Because in highly acid soils it is difficult for most cultivated plants to feed on phosphorus, liming has another function besides making the soil favorable for legume nodulation or furnishing calcium and magnesium: it makes the phosphorus uptake easier.

Although rock phosphate is probably present in the unweathered till and loess, it is not found in detectable amounts in surface soils in a natural available form. Rock phosphate is soluble in dilute mineral acids, and in very acid soils the soil acids slowly attack and dissolve it, causing it to go into the naturally available forms described above. In very sweet soils (pH 6.5 to 7), and especially those on the alkaline side, as carbonate-containing soils, rock phosphate dissolves only very slowly, being retarded by the large supply of calcium associated with a high pH, as well as by a lack of acid.

But in the pH range usually found in carefully limed soils, plant roots can feed on the rock phosphate, and it is therefore classed as available, although for many plants its availability is limited. Unlike the other forms, its solubility--and hence its availability--is not increased by concentration. For these reasons all the root hairs should be given a chance to feed on particles of rock phosphate.

The application of relatively small amounts of rock phosphate by drilling or hill-dropping does not increase its solubility or effectiveness. This is the reason it is necessary to broadcast the full requirement and to mix it thoroughly. Only in this way can most of the roots get a chance to feed on the slowly soluble rock phosphate. The roots in one area cannot obtain extra phosphate to make up for the lack of phosphate in another area, as is true with the adsorbed and other acid-soluble forms. The roots in all areas must have a chance to feed on rock phosphate.

But even when rock phosphate is well mixed throughout the soil, some kinds of plants do not use rock phosphate efficiently and the early stages of growth may be retarded because of a lack of phosphorus. Wheat and tomato yields are likely to be low unless some superphosphate is used for "starter" effect. The superphosphate will give the young plants a good start and they will feed rather effectively on the rock phosphate during the rest of their growth period. Wheat can be set back from 3 to 10 or more bushels per acre if soluble phosphates are not applied, even when four or more tons of rock phosphate per acre have been used.

Most phosphate fertilizers (rock phosphate is an exception) are readily soluble and react with the soil as described above. The proportion of the so-called acid-soluble and adsorbed forms appears to be controlled by the pH (acidity) of the soil. The relative availability of these forms is not known. Liming changes part of the adsorbed forms over to acid-soluble forms and thus increases the amount removed by those soil tests which dissolve principally the acid-soluble forms. This makes it appear as though liming has increased the amount of available phosphorus, whereas it may be only an alteration within available forms.

The amounts of these natural available forms of phosphorus needed for optimum yields are surprisingly large. This is true for untreated cropped soils where the available phosphorus is more or less evenly distributed (not concentrated into patches of higher availability). Around 160 to 300 pounds per acre (2,000,000 pounds) of phosphorus (P, not P_2O_5) are required when this amount is rather thoroughly mixed with the soil as is the case with cropped soils which have not had recent applications. On the other hand "low" testing soils contain around 60 pounds of available P. (The soil test (P_2) removes only about one-third of the total available amount so the soil test value must be multiplied by 3 to obtain the actual value.)

But if a soil contains 60 pounds of available phosphorus (tests low) and if the amount which should be present (thoroughly mixed with the soil) for optimum yield is 200 pounds, it does not follow that the soil must be treated with 140 pounds of soluble phosphorus.

Soluble phosphates, when first added, especially when extreme mixing has not occurred, are much higher in availability

due to the fact that concentration increases the solubility of the adsorbed forms as well as the positional availability for root feeding. So instead of 140 pounds of phosphorus an amount as low as 40 or 30 pounds or less may be sufficient depending upon how it is used and the kind of crop. But it must be repeatedly used until the soil level is sufficiently high to permit just the application of maintenance amounts. Recommendations for the use of soluble phosphates (superphosphate is an example) are thus not generally designed to build up the soil level all at once. They are mainly for the crop to which they are applied. Usually more is added than is removed and a build-up of available phosphorus gradually occurs. But this build-up is a natural by-product of the practice, not the objective. Only highly soluble phosphates can be used in this way. Slightly soluble and slowly soluble phosphates like rock phosphate cannot be used in this way.

Large amounts of rock phosphate must be broadcast and thoroughly mixed with the soil for satisfactory results. But even when added in the proper amounts and thoroughly mixed, rock phosphate does not satisfy all crops and for some a "starter" of soluble phosphate is necessary.

The Soil Organic Matter (humus)

Soluble phosphate is liberated when soil organic matter decomposes. This phosphate goes into the natural available forms and helps explain why the soil test values on untreated soils do not decrease proportionally with crop removals. Because this release of phosphorus from the soil organic matter is uniform throughout the soil, it is not concentrated into patches as happens when soluble phosphates are added. The phosphate released will have no higher an availability than the naturally occurring available forms into which it changed. This release may amount to only 3 or 4 pounds a year, and it adds very little to the effectiveness of the 60 to 130 pounds of available phosphorus already present in deficient soils. But it can have a relatively large effect on the maintenance of phosphorus, since some rotations remove not much over 10 pounds of phosphorus each year.

Roger H. Bray
3/23/53

THE NATURE OF AVAILABLE NITROGEN IN SOILS

The natural available forms of nitrogen in soils are ammonia and nitrate, which are present as the ammonium ion (NH_4^+) and the nitrate ion ($^-NO_3$). Both forms can be taken up from the soil and utilized by most plants. A few plants--rice is an example--must have the ammonium form almost exclusively. But most plants, although they absorb and can utilize both forms, must have a great part of their nitrogen in the nitrate form and do not actually have to have any in the ammonium form.

This may or may not be related to the fact that nitrate nitrogen is the ultimate available form in soils. All other fertilizer forms, through the action of soil microorganisms, can be converted into ammonia and ultimately into nitrate nitrogen.

The nitrogen in soil humus is not in an available form, but its decomposition by soil organisms slowly releases some available nitrogen each year, the amount varying with the amount of nitrogen in the humus and the favorableness of the soil and season. The protein in organic matter, such as crop residues, green manures, or barnyard manures, goes through a decomposition cycle which finally liberates a good share of its nitrogen as ammonia and nitrate nitrogen.

The most common nitrogen fertilizers are ones consisting either of the nitrate or the ammonium form or both. Organic fertilizers like guano or dried blood decompose to ammonia and then to nitrate.

Urea and cyanamid likewise decompose to ammonia and nitrate (cyanamid can harm crops and must be added 10 days before planting.

But regardless of what fertilizer or organic form is added, it is changed to ammonia and nitrate before it is used by plants.

Difference Between Ammonia and Nitrate

There is a fundamental difference in the way ammonia and nitrate react in the soil:

The negatively charged nitrate ion remains free and mobile in the soil. Not being adsorbed by the soil clay, it is free to move in and with the soil water. It will move into the root as the root adsorbs water or will move up to the surface of the soil and be deposited as a salt as the soil dries out.

This salt will be mainly calcium nitrate with some magnesium and potassium, depending on the relative amounts of Ca, Mg, and K on the base-exchange surfaces of the soil. The relative amounts of the exchangeable bases control the proportion of these bases that will be partners of the nitrate ion.

Because of its high mobility in relation to the mobility of the adsorbed forms of nutrients, nitrate nitrogen is highly available and crops can remove it almost quantitatively from moist soils. Leaching rains can also remove it. However, in the silt and clay loam soils of the corn belt, loss of nitrogen thru leaching does not appear to be a very serious problem, particularly while crops are growing. Because nitrate depends on water for its mobility, dry periods can immobilize it before the plant gets it and cause a drought-induced nitrogen deficiency.

The ammonium ion (NH_4^+) is positively charged and reacts with the clay mineral

and humus base-exchange surfaces. This adsorption by (reaction with) the clay-humus exchange surfaces results in almost all of the ammonium ions being held on these surfaces and protected against leaching. Being adsorbed in this way, ammonia is much less mobile in the soil and hence is a temporarily less available form than nitrate nitrogen. But this does not mean that any more of the ammonium form is needed for equal results; its change to nitrate is rapid when growing conditions are favorable. As soil temperatures fall somewhere below 60° to 55° in the fall or spring, the ammonia present in the soil is, for practical purposes, no longer changed to nitrate and, being held on the clay humus surfaces, is protected against leaching during cold periods.

Because all nitrogen fertilizers, except those used by soil microorganisms, are eventually changed to nitrate nitrogen, which is mobile in moist soils, it usually does not matter what method of application is used. Plowed under or broadcast and disked ahead of planting, drilled alongside the rows or in the middle of the rows--all of these methods are generally effective.

Timeliness of application is, however, important in the utilization of added nitrogen by microorganisms or its possible loss by leaching. Delaying part or all of the application could give a somewhat more efficient use under some conditions. But if late applications are broadcast or side-dressed on dry soil surfaces, they will be ineffective until rains wash them into the soil.

When soils are sandy and (or) leach readily, the nitrogen application may be split into two or three applications to reduce the chances of its being partially lost by leaching.

Wet and (or) cold springs delay nitrate formation, as does dry weather.

When ammonia is added as a gas (anhydrous ammonia), it must be released below the surface in such a way as to give it a chance to react with sufficient clay-humus surfaces. This reaction is rapid because it is a neutralization reaction and the soil is, for the time being, somewhat sweeter.

Roger H. Bray
4/6/53

UNIVERSITY OF ILLINOIS · COLLEGE OF AGRICULTURE

AND TESTING

AGRONOMY FACTS

SF-5A

PRINCIPLES OF FERTILIZER USE BASED ON SOIL REACTIONS

1. Phosphates

The way in which fertilizers react with the soil and the products that result determine in large part how fertilizer materials should be used.

The simplest example is ground rock phosphate. In highly acid soils the rock phosphate particles dissolve very slowly, making the phosphate more available, but plants cannot grow well enough in such soils to make use of the phosphate. In less acid soils the particles dissolve less slowly, and in normal soils they remain largely as they were when applied.

Plants can feed to varying extents on rock phosphate. Because it is so insoluble and reacts so slowly, the root hairs that contact and feed on the particles have difficulty in obtaining enough phosphate for the plants. When the root hair first contacts the phosphate particle, it can rather rapidly remove the thin surface film of already dissolved phosphate. But from that time on, the roots feed only as fast as the particles can dissolve.

For this reason some crops never get enough phosphate from rock phosphate alone. The small grains, particularly wheat, and probably the grasses need supplemental additions of soluble phosphates. Wheat following soybeans may produce only two-thirds of a normal yield with rock phosphate alone. To get a good yield, it is necessary to drill soluble phosphate in at seeding time.

Instances where large amounts of rock phosphate have produced as high yields as adequate amounts of superphosphate are rare and do not disclose the true differences between the two forms. When tests show yields to be as high with rock phosphate alone as with superphosphate, it is because the natural forms are helping out, the soil has become acid enough to help dissolve the rock phosphate, or the soluble phosphates were not used in adequate amounts.

Because the rock phosphate particles dissolve so slowly, as many root hairs as possible must feed on them in order to make most efficient use of the phosphate. This means that the rock phosphate should be broadcast and <u>thoroughly mixed</u> with the soil by repeated diskings. Broadcasting and plowing without mixing, or drilling in small amounts in the row with the seed, permits only a small part of the root hairs to feed on the phosphate. A small number of root hairs feeding luxuriantly on rock phosphate cannot make up for a larger number getting a deficient supply. Broadcasting followed by thorough mixing allows the roots to make maximum use of the phosphate.

Another problem in using rock phosphate is that calcium and a high pH decrease the rate of solution of the rock phosphate particles. Soils containing calcium carbonate therefore require soluble phosphates. When rock phosphate is applied at the same time as limestone, the limestone markedly reduces the soil's response to the rock phosphate. This reduction can be prevented by adding superphosphate at the same time. The adverse effect wears off in time as the limestone does its job of neutralizing the soil.

Soluble phosphates present an entirely different problem. Superphosphate, treble super, and meta phosphate are examples of soluble phosphates. When a

soluble phosphate is added to the soil, it dissolves in the soil water and is changed almost immediately into the natural available soil forms. Although the chemistry of these natural soil forms is not fully understood, their division into adsorbed and acid-soluble forms seems warranted (see S.F.-3).

An adsorbed form will be used for illustration. A phosphate ion from the dissolved phosphate--for example, an $^-H_2PO_4$ ion--moves to a broken edge of a clay mineral lattice and changes places with an ^-OH ion on the lattice edge. Now the phosphate ion is tightly held and is no longer in solution. But as more phosphate is adsorbed, the phosphate ions are held less tightly. In short, the phosphate ions on the clay are in equilibrium with the phosphate ions in the soil water. The larger the amount adsorbed, the larger the amount in the soil water.

For this reason if the phosphate is broadcast and thoroughly mixed with the soil, only a small amount will be present on the clay surfaces throughout the soil, and equilibrium will result in a low concentration of phosphate in the soil water.

Such thorough mixing is, however, practically impossible. What actually happens is that the soluble phosphate reacts with the first soil it contacts and becomes highly concentrated in small areas, leaving large areas untouched. When numerous enough, these small areas of phosphate concentration serve as adequate feeding areas for the plant roots.

In contrast to rock phosphate, the added natural available forms of phosphate dissolve readily enough to permit the root hairs to feed luxuriously and, by obtaining more than their share, to make up for the deficiency in the untreated areas. The higher this deficiency, the larger will be the amount of soluble phosphate used, and hence the greater will be the number of areas that are high in adsorbed phosphate.

Soluble phosphates should therefore not be mixed thoroughly with the soil. If large amounts are applied, they should be broadcast and disked into the soil. When possible, smaller amounts, like 100 to 200 pounds, should be drilled or banded near the seed.

Broadcasting without mixing causes the soluble phosphates to be adsorbed mostly in the surface quarter to half inch or so. Even though the phosphate were dissolved in water before being added to the soil, it would still be adsorbed in the immediate surface. Roots can feed on it effectively when the surface is moist, but not when the surface is dry, as it so often is. For pastures, however, this method is often necessary and practical.

The objective is to use the soluble phosphates in such a way that they will become available to the greatest extent both chemically and positionally. High solubility increases chemical availability. Placing the phosphate close to the seed increases positional availability. For example, soluble phosphates will not be so effective if drilled in the middle of corn rows.

Roger H. Bray
5-11-53

AGRONOMY FACTS

PRINCIPLES OF FERTILIZER USE BASED ON SOIL REACTIONS

1. Potassium, Sulfur and Boron

The chemistry of potassium is the chemistry of base-exchange, because the dominant natural available form of potassium is the exchangeable potassium. Potassium is added to the soil as soluble salts that dissolve and ionize in the soil water. Muriate of potash (potassium chloride) is the most common fertilizer form.

Muriate of potash, KCl, dissolves in the soil water as a positively charged potassium ion, K^+, and a negatively charged chloride ion, ^-Cl. The chloride ions cannot react with anything in the soil to make them become less abundant in the soil water. But the positively charged potassium ions can take part in base-exchange.

As positive ions the potassium ions can replace other positive exchangeable ions on the surfaces of the clay minerals and soil organic matter. They are then held immobile on these surfaces unless or until other ions displace them and release them again into the soil water. How much of the potassium remains in the soil water at equilibrium depends on how much is added and what the base-exchange capacity of the soil is.

Because in most agricultural soils calcium and magnesium ions are most abundant on the exchange surfaces, they are the ones that exchange most readily with the potassium and are released most abundantly into the soil water after potash salts are added. This is particularly true of calcium. Exchangeable hydrogen, the acid ion that causes soil acidity, dominates only in highly acid soils.

Therefore, when muriate of potash is added to a soil, the K^+ exchanges with the positive ions on the base-exchange surfaces, and the soil water contains mainly calcium chloride with a smaller amount of magnesium and very small amounts of potassium and hydrogen chlorides. Most of the potassium attaches itself to the surfaces of the soil clay and organic matter as exchangeable potassium.

While this exchange reduces the availability of the potassium, it does not make it unavailable (see Agronomy Facts SF-2) because exchangeable potassium is the natural available form. As the plant roots feed on the potassium in the soil water, more potassium is released to reestablish the equilibrium. By this process the potassium is effectively removed by the plant roots in the denser part of the root system feeding zone.

Just as soluble phosphates remain more highly available if concentrated into small areas instead of being mixed thoroughly with all of the soil, so potassium is more available if it is not thoroughly mixed. This means that soluble potash fertilizers, when used in small amounts, should also be drilled or hill-dropped near the seed. Large amounts should be broadcast and disked <u>into</u> the soil with as little mixing as possible.

Here again, as with phosphates, broadcast surface applications for pastures are a practical and often necessary expedient rather than an ideal way to apply the fertilizer.

In contrast to phosphate use, caution must be observed in applying potash salt close to the seed. Phosphates do not leave soluble salt or acid residues after reacting with normal agricultural soils, and therefore they may be used rather freely. But potassium chloride leaves as much soluble salt after reacting with the soil as before the reaction. The only difference is that afterwards the salt is mostly calcium chloride instead of potassium chloride. The amount that can be placed near the seed is therefore limited.

Some crops are less sensitive to salt than others. Soybeans appear to be especially sensitive. Recommendations for the use of muriate of potash should, and usually do, recognize this fact. No recommendations for amounts to use are being given because our purpose here is only to explain the nature of the soil reactions and to show how they influence the amounts used and the way in which they are used.

Potassium sulfate is another, but less common, form of potassium fertilizer. It is obtainable commercially only in limited amounts. When soils contain a large amount of exchangeable calcium, the danger of damage to crops from the effect of the salt should be lessened by using potassium sulfate instead of potassium chloride. The reason is that, although calcium chloride is highly soluble, calcium sulfate is not. It will precipitate out when the concentration in solution exceeds the solubility of the calcium sulfate.

<u>Boron and sulfur</u>. Besides the ultimate available form of nitrogen, nitrate nitrogen, there are two other nutrients, boron and sulfur, that soils do not adsorb to any marked degree. Boron, in the form of borax, $Na_2B_4O_7$, probably changes in the soil to boric acid, H_3BO_3, which, because it is not adsorbed, will eventually be lost by leaching if not taken up by crops.

The available soil form of sulfur is sulfate, $^{--}SO_4$. In soils it is present mostly as $CaSO_4$. While calcium sulfate is not very soluble, it is sufficiently soluble to make it appear doubtful that there is any undissolved calcium sulfate in normal soils of humid regions. The so-called slick spots of southern Illinois are one exception. So far as we know, the sulfur resulting from the decomposition of the soil humus and from coal smoke in industrial areas is sufficient for crops, and the sulfate in the drainage water is proportional to the amount in the rainfall.

The information on fertilizer use given here does not include directions on <u>how</u> to use fertilizers; rather, it is an explanation of the principles behind the use of fertilizers. Knowing the principles makes it possible to use fertilizers intelligently--to modify standard recommendations to fit local situations without violating the principles. At the same time expediency of use must also be considered. The "perfect" use of a fertilizer must often give way to the "expedient" use, such as broadcasting fertilizer on pastures without working it in.

Roger H. Bray
5/11/53

PRINCIPLES OF FERTILIZER USE BASED ON SOIL REACTIONS

3. Nitrogen and Mixed Fertilizers

Nitrogen. All nitrogen fertilizers have one thing in common: if they are not already nitrate in form, they finally end up as nitrates in the soil--except for the small part which the plant absorbs as ammonia (SF-4).

In the soil all organic forms of nitrogen, such as urea and cyanamid, are changed first into ammonia and then into nitrate nitrogen. If ammonia were the ultimate available form used by the plant and the change to nitrate did not occur, then nitrogen fertility would be similar to potassium fertility and we would be concerned with nitrogen as ammonia, which is an exchangeable base. Placement in the soil would then become important, as it is with soluble phosphate and potash salts.

But because all nitrogen fertilizers can be ultimately changed into nitrate nitrogen, and because the nitrate ion is not adsorbed by the soil, nitrogen fertilizers can be applied in almost any way and they will still be almost completely available for use by plants. An exception is the part used in biological reactions or lost by leaching.

This means that nitrogen fertilizers can be broadcast and plowed under, broadcast and disked, broadcast or side-dressed on the surface without disking, drilled in the row, or drilled between rows or between alternate rows. Usually these methods are about equally effective. Time of application does, however, make some difference. Theoretically, in average seasons, corn should be able to make most efficient use of nitrogen when it is applied at the second cultivation. Actually, however, too often wet weather makes it impossible to apply the fertilizer at this time, or dry weather prevents its efficient use by the plant. In other words, too often the season is not "average."

Because nitrates are not adsorbed by the soil, the nitrate forms of fertilizer should be used with caution, and large amounts should not be placed near the seed.

Soil organisms use the available forms of nitrogen in decomposing organic matter. For example, bromegrass sods containing only a little alfalfa will use up soil nitrogen rather than serve as an immediate source of available nitrogen. This biological reaction must always be considered in estimating nitrogen requirements. On sandy soils the possible loss of nitrogen by leaching must also be considered. Leaching is not due to a soil reaction but results from failure of nitrates to react with the soil.

Mixed fertilizers are combinations of various fertilizer materials except rock phosphate. These mixtures should be used according to their composition. If they are high in soluble phosphates and low in muriate of potash, the salt effect will be low (the phosphate has no salt effect) and larger amounts can be applied in the row or hill. If they are high in muriate of potash or nitrate nitrogen, or both, correspondingly lower amounts should be used. How much soluble salt they will leave in the soil and how sensitive the crop is to the salt will mainly determine how much of the mixed fertilizer can safely be applied near the seed.

The method of applying the fertilizer also helps to determine how much should be used. For example, if a soil is not too deficient, a small amount of fertilizer applied in the row or hill-dropped may be as effective as a much larger amount broadcast and disked in.

But if the deficiency is great, the soil may need more fertilizer than can safely be applied by this method. Broadcasting and disking then become necessary. Whether part of the fertilizer should be drilled in the row for "starter effect" depends on the kind of crop and the soil deficiencies involved.

Roger H. Bray
5/11/53

KINDS OF NITROGEN FERTILIZER

Different nitrogen fertilizers when used properly and under comparable conditions and at equal amounts of nitrogen can be expected to give similar crop responses. In some cases, however, differences in the properties of the various carriers may influence their use. Some information about these different properties and the behavior of nitrogen in the soil is given below:

1. Nitrate nitrogen is the form utilized most extensively by field crops, but considerable amounts of ammonium nitrogen are also readily used.

2. Nitrate nitrogen is released from the soil organic matter by microorganisms. The nitrate formed by this decomposition is identical with that added in fertilizers. The amount of nitrate present or being formed in a soil at a particular time depends on the kind and amount of organic matter that is present. Activity of the microorganisms is also influenced by soil conditions--little nitrate is formed if the soil is too wet, too dry, too cold, or very acid.

3. Nitrate nitrogen is not held tightly by the soil and can move with the soil water. When water moves through the soil, any nitrates that are present can be expected to leach in considerable amounts.

4. The ammonium form of nitrogen is attached to soil particles and does not leach appreciably. Ammonium nitrogen is converted by soil microorganisms to nitrate nitrogen, which is not held by the soil. This conversion is probably complete in two weeks if the temperature and moisture conditions are favorable.

In a cold soil, the conversion is very slow, and little change of ammonium to nitrate nitrogen occurs at soil temperatures below 55° to 60° F.

In general, greater efficiency of nitrogen fertilizer (more response per pound of nitrogen) is obtained when the nitrogen is applied shortly before it is used by the crop. Larger amounts of nitrogen will probably be required for similar returns if the fertilizer is applied at longer periods ahead of the crop.

Frequently convenience and market conditions almost dictate that nitrogen fertilizer be applied for corn during the preceding winter. Efficiency of such fall and winter applications has not been established. Soil permeability, form of nitrogen applied, soil temperature, and amount of rainfall would apparently influence efficiency.

Losses would be expected to be smaller when such applications are made after cold weather begins and when the nitrogen is in the ammonium form. Greatest flow from tile drains usually occurs in the spring before soil temperatures are high enough for extensive nitrate formation. A reduction in losses would also be expected if the nitrogen were plowed down with crop residues, such as straw or cornstalks, which are low in nitrogen.

Nitrogen fertilizer may be applied to sod and pasture crops at almost any time of year, since little leaching occurs under sod crops.

Nitrogen in fertilizers is on the market in solid materials, in anhydrous ammonia, and in nitrogen solutions.

Solid materials are usually either pellets or salt-like crystals packed in moisture-resistant bags. These materials

are usually applied with conventional fertilizer spreaders or side-dressing equipment. Some of these carriers are:

Ammonium nitrate, NH_4NO_3, contains about 33 percent nitrogen, of which one-half is in ammonium form and one-half in nitrate form.

Ammonium sulfate, $(NH_4)_2SO_4$, contains 20 to 21 percent nitrogen, all of which is in ammonium form. It may be of synthetic origin or a by-product of coke produced in the steel industry.

Urea, $(NH_2)_2CO$, a synthetic product, may contain up to 46 percent nitrogen ("Nu-Green" is largely urea; Uramon, a coated granular urea, 42% N). Urea reacts with water in the soil and is converted in a few days to the ammonium form.

Cyanamid, a synthetic product containing around 20 percent nitrogen, is black in color and is usually pelleted. The nitrogen is present as the compound $CaCN_2$, which is diluted by the manufacturing process with carbon and hydrated lime. $CaCN_2$ is not used directly by plants but must first decompose in the soil.

Normally in this decomposition urea and then ammonium nitrogen is formed. Under some conditions (alkaline or poorly drained soils) temporary, intermediate compounds that are toxic to plants are formed during the decomposition.

Cyanamid is usually broadcast or plowed down ahead of the crop rather than banded near the row so that any toxic materials will not be concentrated and injure the crop.

Sodium nitrate, $NaNO_3$, which may be synthetic (Arcadian) or refined Chilean nitrate (Champion), contains 16 percent nitrogen, all in the nitrate form.

Modified forms of the different carriers mentioned above are also on the market. A.N.L., containing 20 percent nitrogen, is ammonium nitrate that has been mixed and pelleted with dolomite to improve handling characteristics. Cal-nitro and nitro-lime are similar products.

Nitrogen in mixed fertilizers is usually in the ammonium form, although carriers containing other forms are also used to some extent.

Anhydrous ammonia is shipped and handled as a liquid under pressure. When pressure is released, the liquid evaporates very quickly to ammonia gas. The liquid is released by the applicator machinery in the soil, where it reacts with the soil water and the clay particles. Because of the special pressure equipment that is required, anhydrous ammonia is usually applied by the dealer.

Nitrogen solutions are ammonia, ammonium nitrate, or urea, or a mixture of two or more of these in water. These solutions are usually sprayed on the soil surface and disked or plowed into the soil. Nitrogen solutions are also used for side-dressing row crops where the solution runs from a small pipe behind the cultivator shovel. Because these solutions are corrosive, stainless steel or aluminum equipment is ordinarily used.

A nitrogen material in water solution will be no different from the solid material in its reaction with the soil and its effect on crop growth.

Some nitrogen solutions are listed below. similar solutions put out by different companies may have different names.

Nitrogen solution 32 contains around 15 1/2 percent nitrogen as ammonium nitrate and 16 1/2 percent nitrogen as urea, or a total of 32 percent nitrogen.

Nitrogen solution 4 contains 37 percent nitrogen, about two-thirds of which is ammonium nitrate and one-third anhydrous ammonia. This solution has about 1 pound pressure at 104° F. Salt will begin to crystallize out at 48° F.

Nitrogen solution 2A contains 40% nitrogen and is also a mixture of ammonium nitrate, ammonia, and water. It contains more ammonia and has around 10 pounds pressure at 100° F. and begins to salt out at 23° F.

Other nitrogen solutions are also being manufactured. One group containing urea and ammonia in water is known as U.A.L. solutions (urea-ammonia liquors).

L. T. Kurtz
5/4/53

AGRONOMY FACTS

SF-7

THE ILLINOIS SOIL TESTING PROGRAM

The farmer gets from his farm adviser a sheet, "Directions for Collecting Soil Samples From a Forty-Acre Field," describing how to sample his fields. He also gets an "Information Sheet" to fill out, giving the farm adviser information about the kinds of soil and previous treatment.

After he has taken his samples and completed the information sheet, he takes the samples to the farm adviser to be tested in the county soil testing laboratory for limestone (acidity), available phosphorus, and available potassium. Counties that have no laboratories send their samples to the University Soil Testing Laboratory.

A technician, trained at the University laboratory, runs the samples and gives the results to the farm adviser who, in conference with the farmer, outlines a program of limestone and fertilizer to be used for each field tested. The farm adviser uses pamphlets AG1198 and AG1220 as guides in interpreting the tests.

How Technicians Are Trained

Because of limited staff and facilities at the University laboratory, acceptance of applicants for training must be limited to persons and laboratories planning a complete and regular soil testing service for acidity, phosphorus, and potash. No one will be trained who expects to test only occasionally.

In order to maintain an accurate and dependable soil testing service, those who are accepted for training will be expected to agree to the following:

1. To spend at least two days in the University laboratory for training in testing soils (unless they can submit satisfactory evidence of previous training).

2. To submit eight check samples to the University laboratory every month while the county laboratory is testing soils. No charge will be made by the University laboratory for running check samples for acidity, phosphorus, and potassium.

Anyone who plans to establish and operate a soil testing laboratory should first write for information and an application blank to

A. U. Thor
Agronomy Soil Testing Laboratory
Davenport Hall
Urbana, Illinois

As of December 1952, there were 80 county soil testing laboratories and 18 commercial soil testing laboratories on our accredited list. The University laboratory also tests soil samples for acidity, available phosphorus, and available potassium. In addition to these standard tests, the soil can be tested for boron, but an additional charge is made.

Available Information on Soil Testing

On the back of this page is a list of pamphlets describing how we take and prepare soil samples, run the samples in the laboratory by the quick methods, and interpret the results in terms of limestone, phosphate, and potash needs for corn-belt conditions.

PAMPHLETS AND LEAFLETS DESCRIBING THE TESTING PROGRAM

For the Farmer

M 397	- Directions for Collecting Soil Samples
3-48-38074	- Information Sheet and Soil Test Report

For the Technician

AG1275	- Photometer Method for Determining Available Potassium in Soils
AG1306	- Photometer Method for Determining Available Phosphorus in Soils
AG878	- Potassium, Phosphorus and Other Tests for Illinois Soils
AG1028	- Rapid Tests for Measuring and Differentiating Between Adsorbed and Acid-Soluble Forms of Phosphate in Soils
AG1268	- Leaflet Describing Acidity and Phosphorus Tests

For the Farm Adviser and Farmer

AG1388	- The Illinois Soil Testing Program
AG1342	- Nitrate Tests for Soils and Plant Tissues
AG1257	- Directions for Using Nitrate Powder on Corn Plants

For the Farm Adviser

11-47-36976	- Soil Test Maps
AF1220	- Soil Test Interpretation and Fertilizer Use
AG1198a-h	- Standard Rotation Requirement Tables
AG1359	- Maintenance Requirements for Fertile Soils
AG1374	- Equipment Needed for Complete Soil Testing Laboratory
2-48-37572	- Soil Treatment Recommendations Based on Soil Tests

Book on Soil Testing

Diagnostic Techniques for Soils and Crops, 1155 16th Street, N. W., Washington, D. C., published by American Potash Institute.

A. U. Thor
5/18/53

LEGUMES AS NITROGEN FIXERS

One way in which leguminous crops improve soil productivity is by taking part of their nitrogen from the air and giving some of it to the soil when all or part of the crop is plowed under.

How much nitrogen do legumes add to the soil? The answer to this question depends on several conditions.

One of these conditions is the proportion of nitrogen which the legume takes from the air. Although it is often said that legumes obtain two-thirds of their nitrogen from the air and one-third from the soil, this proportion is not always the same.

Recently a new method was found for evaluating the contribution of leguminous crops to soil nitrogen. In this method two sister selections of soybeans that are alike in all characteristics except nodule formation are used to measure the amount of nitrogen the nodule bacteria contribute to the soil. One of these selections, designated as R, is well nodulated, whereas the other, designated as r, bears no nodules.

Results of two experiments in which these two soybean selections were compared are given below. The crops were grown on limed soils to which phosphate and potash had been applied according to soil tests. The soils differed in their nitrogen-supplying power, however.

Where there was an adequate supply of available nitrogen in the soil, yields were the same for the two selections. Where the available nitrogen supply was low, however, the R selection yielded more than the r selection.

Table 1. Yields of Two Soybean Selections on Soils Differing in Nitrogen

Nitrogen fertility of soil	Soybean selection R	r	Difference
	bu/A	bu/A	bu/A
1. High	36.6	33.1	3.5
2. Medium	36.0	29.2	6.8
3. Low	35.5	20.9	14.6

Selection R, which was well nodulated, had practically the same yield on all soils regardless of nitrogen fertility; but selection r, which was not nodulated, declined in yield as nitrogen fertility declined.

An analysis of the plant tops and roots and comparison of the results made it possible to estimate the proportion of total nitrogen that the soybean selection R had obtained from the air.

Table 2. Nitrogen Content of R and r Soybean Selections on Three Soils

Soil	Total nitrogen in selection R	r	Air-derived nitrogen in selection R
	lb/A	lb/A	perct.
1	199	158	21
2	192	102	47
3	177	65	63

As the nitrogen fertility in the soil decreased, the proportion of nitrogen secured from the air increased and the value of the nodule bacteria increased.

If we assume that a corn crop could take the same amount of nitrogen from these soils as the r selection (unnodulated) and that 1 1/2 pounds of nitrogen are sufficient to produce 1 bushel of corn, we can then conclude that, on soils having a nitrogen fertility sufficient for 100 bushels of corn per acre, only one-fifth of the nitrogen in soybean crops grown on such soils would come from the air. On soils having a nitrogen fertility sufficient for only 40 bushels of corn, under favorable conditions nearly two-thirds of the nitrogen in the soybean crop would be air-derived.

Although we have no tools for measuring exactly the effect of available nitrogen on the ability of other leguminous crops to fix nitrogen, it is reasonable to assume that the same principle would apply to them.

Thus it would appear that natural processes set a ceiling on nitrogen fixation for each environment and that, as the nitrogen content of the soil approaches this ceiling, it becomes more difficult for nodulated legumes to add nitrogen to the soil. As the nitrogen fertility of soils decreases, other factors being favorable, the contribution of nodulated legumes increases. But as the nitrogen fertility increases, the amount of nitrogen added by legumes decreases. Thus it is difficult to raise the level of soil nitrogen beyond a certain amount by using legumes, and this fixed amount will vary with different soils.

O. H. Sears
6/1/53

AGRONOMY FACTS

SF-9

FOLIAR SPRAY APPLICATION OF FERTILIZER MATERIALS

Since it has been shown that a large number of the essential plant nutrients can be absorbed through leaves of plants, considerable interest in adding nutrients to plants in this way has occurred during the past few years. Most of the available experimental data on the comparison of foliar spray and soil application of nitrogen on the yield of corn and wheat are presented here.

Comparison of Foliar Spray and Soil Application of Nitrogen 1/ on Yield of Wheat
(Hauck and Earley, Illinois. 1951)

Method of application	Date applied	Conc. of fert. in spray	Yield (bu./A) Urea	$(NH_4)_2SO_4$
Check	....	....	26	30
Top-dressed	April 26	....	36	45
Sprayed	April 26	1 lb./gal.	35	42
Top-dressed	May 12	....	33	43
Sprayed	May 12	1 lb./gal.	32	37
Top-dressed	May 22	....	..	37
Sprayed	May 22	1 lb./gal.	30	27

1/ 40 pounds of N per acre added.

Authors' conclusion: Spraying nitrogen on wheat plants had no advantage over top-dressing. In both methods the earliest applied nitrogen gave highest yields.

Comparison of Foliar Spray and Soil Application of Nitrogen 1/ on Yield of Wheat
(Smith, Kansas. 1952)

Method of application	Date applied	Conc. of fert. in spray	Yield (bu./A) Urea	NH_4NO_3
Top-dressed	April 25	8 lb./gal.	..	37
Sprayed	April 25	8 lb./gal.	33	33
Top-dressed	May 3	8 lb./gal.	..	33
Sprayed	May 3	8 lb./gal.	29	30
Top-dressed	May 17	8 lb./gal.	..	29
Sprayed	May 17	8 lb./gal.	27	28

1/ 50 pounds of nitrogen per acre added.

Author's conclusions: (1) Nitrogen fertilizer may be sprayed on wheat foliage, but this type of application is less effective, especially with respect to yield, than are applications made to the soil. (2) Since financial returns for the use of nitrogen fertilizer on wheat normally depend on increases in yield rather than on increases in protein content, there is no good reason to recommend foliar sprays rather than the conventional dry applications for wheat.

Comparison of Foliar Spray and Soil Application of Nitrogen on Yield of Corn
(Montenegro, Foy and Barber, Indiana. 1952)

Fertilizer	Method of application	Nitrogen added per acre	Conc. of fert. in spray	Yield increases Field A	Yield increases Field B
		lb.		bu./A	bu./A
NH_4NO_3	Side-dressed	20	....	7.0	13.4
Urea	Sprayed	20 1/	1/2 lb./gal.	6.6	13.8
NH_4NO_3	Side-dressed	40	....	9.3	20.6
Urea	Sprayed	40 1/	1/2 lb./gal.	7.5	14.8

1/ Single application.

Authors' conclusion: Application of 20 pounds of nitrogen per acre as a urea spray was no more effective in increasing yield of corn than an equal amount of nitrogen as ammonium nitrate side-dressed. At the 40-pound rate, side-dressing gave the best results.

Comparison of Foliar Spray and Soil Application of Nitrogen 1/ on Yield of Corn
(Hauck and Earley, Illinois. 1951)

Method of application	Date applied	Conc. of fert. in spray	Yield (bu./A) Urea	Yield (bu./A) $(NH_4)_2SO_4$	Yield (bu./A) NH_4NO_3
Check	....	....	81	81	81
Side-dressed	July 2	....	102	116	114
Sprayed	July 17	1 lb./gal.	95	71	66
Sprayed	July 2 and 17	1/2 lb./gal.	104	88	92

1/ 40 pounds of nitrogen per acre added.

Authors' conclusions: (1) These nitrogen fertilizers sprayed on corn plants at the rate of 40 pounds of nitrogen per acre and 1 pound per gallon of solution caused marginal burning of the leaves and reduction in yield compared to side-dressing. Urea caused the smallest amount of leaf damage and the smallest reduction in yield. (2) Two sprayings of 20 pounds of nitrogen per acre at 1/2 pound of fertilizer per gallon of solution gave higher yield than one spraying of 40 pounds of nitrogen per acre at 1 pound of fertilizer per gallon of solution. (3) Side-dressing 40 pounds of nitrogen per acre gave higher yields of corn than spraying, except for the two sprayings of urea, which equaled side-dressing.

Thus far there is little evidence to show that foliar spray application of nutrients to agronomic plants is more efficient in increasing yield than soil application. Until this is shown, it is suggested that soil application of fertilizers be continued according to present recommendations.

Only a few experiments have been reported where phosphorus and potassium compounds have been sprayed on plants. The results indicate that these substances must be added in very dilute solutions in order to prevent burning the leaves.

Foliar spray applications can easily be made to horticultural and truck crops, but the commercial value of this practice remains to be seen.

E. B. Earley
June 29, 1953

AGRONOMY FACTS

SF-10

ILLINOIS SOIL EXPERIMENT FIELDS

The University of Illinois has experiment fields located on most of the important soils throughout the state. These fields are providing information on the responsiveness of soils to livestock and grain systems of management under different liming and fertility practices. The results are measured in terms of crop yields and economic returns. In some cases the physical and chemical changes of the soil have also been measured.

The location, soil association, and soil types (AG1443) of the present experiment fields are presented in the table below. Results for each location are summarized annually. The results for any field can be obtained from the Department of Agronomy. One or two field meetings are held at most locations each year during the summer or fall. These meetings, under direction of University personnel, provide an opportunity for the public to see how research is conducted and how agronomic practices affect crop growth. In addition, agricultural workers may use the fields for tours or educational programs or meetings of their own.

Other publications based on results at the soil experiment fields are Illinois Bulletin 516 and Agronomy mimeograph AG1512. Bulletin 516 contains a comprehensive summary of the research on soil experiment fields from the establishment of the Morrow plots in 1876 through 1942. The effects of manure, crop residues, limestone, phosphate, and potash on crop yields and net income are discussed. AG1512 gives a brief report of experiment field results from 1888 through 1950.

Soil assoc. area	Experiment field	County and date established	Description of soils and types
E	Joliet	Will - 1914	Dark soils with slowly permeable subsoils on calcareous slowly permeable till. Chiefly Elliott silt loam.
H	Urbana	Champaign - 1903 and 1928	Moderately dark to very dark soils with moderately permeable subsoils. Chiefly Flanagan-Catlin-Sidell silt loams and Drummer silty clay loam.
K	Aledo	Mercer - 1910	Very dark soils with moderately permeable subsoils. Sable silt loam to silty clay loam.
K	Kewanee	Henry - 1915	Dark soils with moderately permeable subsoils. Chiefly Muscatine silt loam.
K	Dixon Mt. Morris	Lee - 1910 Ogle - 1910	Moderately dark to dark soils with moderately permeable subsoils. Tama-Muscatine silt loams.

Soil assoc. area	Experiment field	County and date established	Description of soils and types
K	McNabb	Putnam - 1907	Moderately dark to dark soils with moderately permeable subsoils. Atterberry-Muscatine silt loams.
K	Hartsburg	Logan - 1911	Very dark moderately heavy soils with moderately permeable subsoils. Il-liopolis silty clay loam.
K	Carthage	Hancock - 1911	Dark soils with moderately permeable subsoils. Ipava silt loam and Il-liopolis silty clay loam borderline to Herrick silt loam and Virden silty clay loam, respectively, of Soil As-sociation Area M.
M	Carlinville Clayton	Macoupin - 1910 Adams - 1911	Moderately dark soils with grayish subsurface and slowly permeable sub-soils. Chiefly Herrick silt loam.
M	Lebanon	St. Clair - 1910	Moderately dark soils with grayish subsurface and moderately slowly per-meable subsoils. Borderline Herrick-Jarvis silt loam (latter soil mapped only by SCS to date.)
O	Enfield	White - 1912	Yellowish-gray strongly leached soils with slowly to very slowly permeable subsoils. Bluford and Wynoose silt loams.
O	Sparta	Randolph - 1916	Yellowish-gray strongly leached soils with slowly to very slowly permeable subsoils. Chiefly Bluford and Wynoose silt loams with frequent slick spots.
O-P	Raleigh West Salem	Saline - 1910 Edwards - 1912	Gray to yellowish-gray strongly leached soils with very slowly per-meable subsoils. Bluford, Wynoose, Hoyleton and Cisne silt loams.
P	Oblong	Crawford - 1912	Dark gray moderately leached soils with slowly permeable subsoils. Chiefly Newberry silt loam.
P	Ewing Toledo	Franklin - 1910 Cumberland - 1913	Gray strongly leached soils with very slowly permeable subsoils. Cisne and Hoyleton silt loams.

Soil assoc. area	Experiment field	County and date established	Description of soils and types
P	Newton Brownstown	Jasper - 1912 Fayette - 1940	Gray strongly leached soils with very slowly permeable subsoils. Chiefly Cisne silt loam and Hoyleton silt loam with frequent slick spots.
Q	Elizabethtown	Hardin - 1917	Yellow soils with slowly permeable subsoils. Similar to Clement silt loam, immature phase.
S	Oquawka	Henderson - 1915	Light brown medium sand with slight to no subsoil development. Oquawka sand.
V	Minonk	Woodford - 1910	Dark to very dark moderately heavy soils with moderately permeable subsoils. Mostly similar to Ashkum silty clay loam but deeper to calcareous slowly permeable till.
X	Dixon Springs	Pope - 1937	Yellowish-gray strongly leached soils with very slowly permeable subsoils. Chiefly Grenada-like silt loam (similar to Ava silt loam of Soil Association Area O.)

A. L. Lang and H L. Wascher
6/15/53

AGRONOMY FACTS

NITROGEN AND SOIL ORGANIC MATTER

Soil organic matter is usually thought of as a residual product consisting of decomposable residues and microbial tissue. The organic matter is essentially the only source of nitrogen in soils.

By analysis, organic matter contains about 5 percent of nitrogen and 0.5 percent each of phosphorus and sulfur. Or, stated in another way, the ratio of carbon to nitrogen to phosphorus to sulfur in soil organic matter is about 100 to 10 to 1 to 1. Most soil organic matter has a carbon-nitrogen ratio varying roughly from 8 or 12 to 1.

Since soil organic matter is the major source of nitrogen for crops on untreated land, it follows that the more intensive the nitrogen removal in crops, the more rapid the organic matter loss. Any treatment that tends to reduce the demand of a crop for soil nitrogen, such as growing legumes or adding manures or nitrogen fertilizers, tends to decrease the rate of loss of both soil nitrogen and soil organic matter. The longer soils are cropped without adding nitrogen in some form, the less the amount of organic matter in the soil.

How low may the organic matter in a given soil be allowed to drop without causing loss of productive capacity due to poor physical condition of the soil? The answer will vary with the soil and its location. Critical levels have not been well established, but it is felt that good farm management programs should aim at maintaining soils at their present organic matter levels.

The maintenance, or build-up, of soil organic matter is determined essentially by the following factors:

1. Nature and amount of organic materials returned to the soil. Legumes are better for this purpose than stover; stover is better than straw.

   Rate of decomposition of residues is influenced by their nitrogen content. Residues that are high in nitrogen (or to which nitrogen has been added) decompose faster than residues that are low in nitrogen. But the total soil organic matter formed increases as the nitrogen content of the residue increases.

2. Soil moisture. Wet soils are more favorable for the formation of organic matter than dry soils.

3. Soil temperature. In general, cooler temperatures favor the formation and retention of soil organic matter.

4. Soil aeration. In general, a well-aerated soil is less favorable for the build-up of soil organic matter than a poorly aerated soil.

   Sands and coarse-textured soils are less favorable for soil organic matter build-up than are the heavier soils.

   Cultivation causes a breakdown of soil organic matter and tends to prevent its build-up in the soil.

5. Soil nutrients. Since soil organic matter is the residual product of microbiological activity, it follows that fertile soils are more favorable for organic matter build-up than infertile soils.

Millar and Turk, on page 257 of their 1951 edition of Soil Science, state: "The accumulation of organic matter in soils is primarily a nitrogen problem. Theoretically, there can be no increase in effective soil organic matter without first a proportionate increase in soil nitrogen. This implies that there is a very constant and close relationship between the nitrogen and organic matter contents in soils. This close relationship does actually exist. Since the ratio of C to N in humus is roughly 10 to 1, it must be concluded that neither carbon nor nitrogen, and hence soil organic matter, can be permanently or appreciably increased or decreased without a corresponding change in the other.

"If the nitrogen content of plant residues is low, added nitrogen will be required to meet the demands of the soil organisms which produce the soil humus. We must, therefore, come to the conclusion that the accumulation or restoration of soil organic matter is a problem of utilizing nitrogen as a means of holding carbon and other materials that constitute humus."

Soil tilth and aeration are influenced by soil organic matter. It is not enough that a soil contains fairly large amounts of total soil organic matter, it must have relatively large amounts of "active" organic matter or residues going through the process of decomposition. It is the actively decomposing residues that seem to be essential for the formation and maintenance of good soil structure and tilth. A good soil management program maintains the level of total soil organic matter and maintains an adequate supply of actively decomposing material for optimum microbiological activity in the soil.

S. W. Melsted
6/22/53

USING BORAX FERTILIZER ON ILLINOIS SOILS

To develop normally, plants must have boron in small amounts. Because the amount is so small, boron is called a minor plant nutrient or a trace element. Too much of it will poison plants; for this reason excess boron is said to be toxic.

Alfalfa shows symptoms of boron deficiency more often than any other crop in Illinois. But other legumes (except soybeans) and some vegetable crops like tomatoes, celery, cabbage, and beets are also sensitive to lack of boron.

In alfalfa the symptoms vary with degree of deficiency and age of the plant. Alfalfa yellows is a common symptom, but rosetting is a more reliable one.

When rosetting occurs, the stems of the upper branches are usually short, giving the plant a bushy appearance. Plant growth is stunted. The terminal bud dies. The leaves become yellow or red. Leaf discoloration may also be caused by insect damage, certain diseases, and deficiency of other nutrients. But discoloration due to boron deficiency is always confined to the terminal or upper growth.

Boron deficiencies have been reported throughout all of Illinois. The soils of southern Illinois are particularly deficient. Sandy and coarse-textured soils are also likely to lack boron, as are those that have lost most of their available boron through crop removal. For example, a field that has had a heavy legume rotation (as in dairy farming) may be expected to be low in available boron.

Boron deficiency in alfalfa is most apparent in dry years and on the second-cutting of alfalfa hay. When boron fertilizer is applied, yields may increase, especially on soils that are highly deficient. On soils that are only moderately deficient, the primary effect will be to increase forage quality. In recent tests in southern Illinois, borax applications have caused remarkable increases in alfalfa seed set. With the proper use of borax, alfalfa seed production may therefore become a distinct possibility in Illinois.

Improper use of borax may, however, ruin a crop. If your soil has not been tested for available boron, use borax only with extreme caution. Do not apply more than 60 pounds per acre (in some states the usual rate is only 15 to 30 pounds). Never apply it at seeding time, but top-dress it on established stands. Do not use it on small grains, corn, or soybeans. These crops are less tolerant than the legumes, and borax can easily injure them. The grasses, however, are quite tolerant, and borax can be used on legume-grass mixtures as well as on pure legume stands.

In most soils boron toxicity rarely occurs naturally. But certain conditions may cause such symptoms to appear. Soybeans are especially susceptible to high concentrations of boron, and there are indications that roses and chrysanthemums may also be susceptible. In all of these cases the main symptom seems to be the dying of a narrow margin of the leaf edges. It usually appears first in the older leaves.

Borax and fertilizer borate are the materials that are commonly used to supply boron; they contain about 11 percent of boron. Because they are dry and granular, they may be spread directly from broadcast spreaders, by tractor-mounted grass seeders, or by hand. Or they may

be mixed with some other material, such as phosphate or potash fertilizer or dry sand, and applied with a regular fertilizer spreader.

It is possible to buy commercial mixed fertilizers containing borax. But they should be used only for top-dressing established stands of legumes and not at planting time. Often, too, they do not contain enough boron to overcome the deficiency unless excessive amounts of phosphorus and potassium are also applied. Such mixtures as 0-9-27B (originally 0-10-30), to which 10 percent of borax has been added, are probably suitable for use on all but the most boron-deficient fields.

You can take soil samples for the available boron test at any time of the year. The sample may be a composite of three or four samples taken for acidity, phosphorus, and potash tests. Or it may be a separate sample made up of six to ten borings from a 10- to 15-acre area. Send the samples to the Soil Testing Laboratory, Davenport Hall, University of Illinois, Urbana.

The boron test costs $2.00 per sample. Because borax fertilizer is of little value if the phosphate and potash requirements of the crop are not fully satisfied, all samples are also tested for acidity, available phosphorus, and available potassium. The $2.00 charge includes these tests.

At present the University Soil Testing Laboratory is making the following recommendations for applying borax fertilizers to soils growing legumes when the tests show them to have the indicated amounts of boron deficiency.

Soil test		Borax recommended for top-dressing on legumes (pounds per acre)		
Pounds of available boron per acre	Test rating	Slowly permeable soils	Moderately permeable soils	Excessively permeable soils
0 - 1	Low	60	40	20
1 - 2	Medium	40	20	0
2 +	High	0	0	0

Darrell A. Russel
6/29/53

Postage paid

AGRONOMY FACTS

FALL VS. SPRING PLOWING

Nearly three million acres of leguminous crops, grown alone or in grass mixtures, are used annually in Illinois for forage and for soil improvement purposes. They occupy the land from one to several years and are usually followed by corn.

The time of year at which to plow these legumes under varies greatly from farm to farm. The farmer must consider many conditions before deciding what is the best time for this operation.

These five reasons are often given for plowing legumes under in the fall:

It improves soil tilth. Many farmers prefer to fall-plow, particularly on heavy soils like clay loams, because they think winter freezing helps to make a better seedbed than can be obtained after spring plowing.

If spring-plowed soils are to have good tilth, they must be plowed when the moisture content is right. On heavy soils, moisture conditions are rarely favorable in the spring. For this reason spring plowing is often done when the soil is too wet or when the season is too far advanced.

Moisture conditions are more favorable in the fall. And, even if the soil is wet when the plowing is done, freezing and thawing will improve the soil structure and consequently result in a better seedbed.

It replenishes available soil nutrients. The idea back of this reasoning is that resting the land permits some of the unavailable plant nutrients in the soil to become available for plant use through biological and chemical changes that occur naturally. Actually, however, these changes are relatively insignificant where the supply of nutrients is maintained by adding fertilizers as soil tests indicate a need for them.

It lessens insect hazards. Although fall plowing alone will not control insects, there is some evidence that it does reduce damage to corn from insects.

It permits better distribution of farm labor by leaving more time in the spring for other urgent jobs.

It destroys weeds. To avoid a heavy infestation of weed seeds, it is necessary to plow occasionally in either late summer or fall or to clip the weeds.

But there are some points on the other side of the ledger. Fall plowing may also do these things:

It may increase soil losses from erosion. Ground cover helps to cut down losses from erosion. On land that is subject to erosion, the losses from this source may more than offset any gains in yields obtained through fall plowing.

It may cause plant nutrients to be lost in the drainage water. Nitrogen in particular may be lost; and the earlier the plowing, the greater the loss. Most of the nitrogen in plant residues is in a form that will not move freely in soil water. But if plowing is done when the soil temperature is above 50° F., the soil microorganisms readily convert the plant nitrogen into nitrate nitrogen, a

from that does move readily with soil water. Thus early fall plowing, when temperatures are favorable for microorganic activity, may cause a considerable amount of loss in the nitrogen that leguminous plants take from the air.

It may decrease nitrogen fixation. The quantity of nitrogen that nodulated legumes add to the soil depends in part on the amount of growth the leguminous crop is able to make. If the legume is plowed under in the same year in which it is seeded, early fall plowing will prevent the plants from fixing the maximum amount of nitrogen.

From these statements it appears obvious that the best time to plow will depend on what objective is to be achieved. If a farmer wants to control erosion, he should not do his plowing in the fall. If he wants to reduce insect damage in his corn, he might fall-plow at the expense of losing some nitrogen by leaching and perhaps by erosion.

Yield is, however, the main criterion that most farmers use in evaluating the worth of any farming practice. And so far there is not much evidence to show that fall plowing is any better than spring plowing in increasing corn yields, although there may be a slight trend in favor of fall plowing.

R. S. Stauffer and O. H. Sears
9-7-53

SOIL TESTS: THEIR CHANGES WITH FERTILIZER APPLICATIONS

Interpretations of soil test values must be based in part on a knowledge of fertilizer and limestone applications during the past five or six years, and preferably longer. It is not possible to obtain representative samples from recently treated soils. Even with the best sampling techniques, the test result must be interpreted not only with due consideration of (1) the amount of a fertilizer material added, but also (2) the kind or form of the material, (3) its reaction with the soil, and (4) the method of application used.

The test of a soil soon after treatment is not a check on whether or not enough has been used. Rather, it is a value influenced not only by the original content, but also by the four factors mentioned above.

Acidity. The acidity in an unlimed soil is fairly uniform in local areas. A composite soil sample adequately represents the situation in the local area. But this uniformity disappears with liming. Even the best of mixing leaves a mixture of neutralized (sweet) and acid spots.

If there are enough neutralized spots within the legume's root systems, adequate nodulation of the roots can take place. The whole soil does not have to be neutralized. A sample from such a soil may be "acid" by the pH measurement and give a red thiocyanate test. But in time, with plowing and cultivating, the limed soil becomes more uniformly neutral.

Because of the lag in neutralization and mixing, the testing of recently limed soils can give no useful information. One cannot add limestone and then test to see whether enough has been added. Five or six years after liming, fairly reliable tests can again be secured. But even then the tests can be better interpreted if one knows the previous liming history. The best procedure is to have the soil tested, broadcast the recommended amount of limestone, thoroughly mix it into the soil, and not test again for five or six years.

Rock phosphate. Erratic soil test values for phosphorus are usually found when soils are tested after the recommended rates of rock phosphate have been applied. If the rock phosphate was thoroughly mixed with the soil, as it should be for good results, one should theoretically obtain tests around medium or above. But complete mixing is difficult, if not impossible, and wide variations in test value are found. Too wide variations indicate that the rock phosphate was not properly applied and mixed.

Soluble phosphates are changed in soils into the natural available soil forms of phosphorus. Because soluble phosphates are so much more highly available when properly applied (see SF-5), ordinarily not enough is used to markedly change the soil test value. Furthermore, when properly applied, the soluble phosphates are not thoroughly mixed with the soil. This results in very efficient plant feeding but also makes it difficult to obtain representative samples.

An amount that is adequate to produce maximum yields is not necessarily enough to make the soil test "high." The added phosphate is more available when not thoroughly mixed than when rather evenly mixed. A soil does not have to test "medium to high" in order to give optimum yields if part of the available phosphate is concentrated in patches or spots where it has a markedly higher solubility and is also positionally more

available for plant feeding. It is possible for two different soils to give the same soil test value and yet vary in their phosphate sufficiency, provided one of them has been treated recently with soluble phosphates.

Each 100 pounds of 20 percent superphosphate contains only 8.7 pounds of actual P, the element phosphorus. The soil test extracts only about one-third of the available phosphorus. A soil test value of 25 pounds, therefore, means an actual value of around 75 pounds. Even though the 8.7 pounds of phosphorus was mixed thoroughly and a representative test was secured, the actual soil test value would be increased by about 2.9 pounds for each 100 pounds of superphosphate (0-20-0), assuming no plant removal. Thus the addition of 200 or 300 pounds of superphosphate would increase the actual test value only slightly. However, uneven mixing, which is the correct way to use soluble phosphates, can result in widely varying test values until plowing and cultivating cause more even mixing.

Potassium is likewise more available to plants when not thoroughly mixed with the soil. When it has been recently applied, representative samples are difficult to secure. The soil test, however, extracts all (not a proportionate part) of the immediately available potassium in the sample that has not been extracted by plant feeding or adsorbed into the "storehouse" (see SF-2). But the sample will not be representative until after plowing and cultivating mix the applied potash.

Nitrogen. The natural available forms of nitrogen are ammonia and nitrate nitrogen (see SF-4). It is easy to measure both of these forms. Additions of commercial nitrogen fertilizers will increase these forms temporarily until the plants remove them, as will also clovers and other crops that are high in nitrogen. But a soil test at any one time gives only the level at that time. Many factors influence the level of these forms in the soil. This makes it impossible to interpret soil tests accurately for available forms of nitrogen. Several states are using methods that try to predict how much will be released during the year. But this is not a direct measure of the available form.

Summary. Reasons why the previous treatment history of a soil should be known have been given above. The soil test measures the amounts of available forms present in a sample. But the plant availability or effectiveness of one amount of a form will depend not only on the chemical properties of the form, but also on its distribution throughout the soil--that is, its fertility pattern or evenness of distribution.

At present the soil tests are calibrated on the basis of the natural type of distribution resulting from plant feeding where no fertilizers have been added. This is a fairly even distribution, with no sharp variations in amount. After fertilizers have been applied and mixed and plowed and cultivated for several seasons, a somewhat similar fertility pattern will finally result.

But if soluble fertilizers (P and K) have been recently added, allowance must be made for the extra availability of the amounts added in interpreting the soil test. There is no "rule of thumb" or scale by which to judge how much significance should be given to recently applied fertilizers. If the amounts added were relatively small, they can be almost ignored. But if the amounts were considerably in excess of subsequent plant removals, the effectiveness of the soluble nutrient will be higher than will be indicated by the charts for the soil test interpretations.

After soils are tested for phosphorus and potassium and a program of soluble fertilizer use has been decided upon, it should be continued for six to eight years. Then retesting is recommended to adjust the treatments for any change in the soil test values.

Roger H. Bray
9-28-53

AGRONOMY FACTS

SOIL FERTILITY MAINTENANCE

A fertilizer maintenance program implies (1) that enough fertilizer will be used to maintain either soil test at optimum levels or yields at optimum, and (2) that the quantity of fertilizer used will contain nutrients equal to, or less than, those removed by crops.

Fertility maintenance is usually practiced only on soils that have an average crop nutrient sufficiency rating of over 90 percent. At the 90 percent level, the use of fertilizer nutrients equal to that removed by crops will give optimum yields.

Maintenance fertilization, then, is the practice of using a quantity of fertilizer, largely determined by the amount of nutrients removed, to get optimum crop yields or to maintain soil test levels at their optimum.

The following table may be used to determine the amount of nutrients removed by some common farm crops:

Nutrients Removed by Common Farm Crops

Crop	Yield level	N lb/A	P_2O_5 lb/A	K_2O lb/A
Corn	100 bu. grain	92	37	24
Wheat	35 bu. grain	43	18	11
Oats	70 bu. grain	43	18	11
Soybeans	32 bu. grain	--	27	35
Legumes	3 tons hay	--	32	102

The first purpose of the maintenance program is to keep the productive level, or yield capacity, of the soil at optimum. For each soil nutrient there is a minimum level that is just high enough to give optimum yields when it is supplemented by enough fertilizer to provide the nutrients equivalent to those removed by crops.

For phosphorus the soil test level at which the use of phosphate fertilizers equal to that removed by plants will give optimum yields and maintain the test level is slight plus (S+). For potassium the minimum test level for maintenance will depend on the soil (see SF-2). In general, for northern Illinois this minimum is about 120 pounds per acre, while for southern Illinois it is about 150 pounds.

The second purpose of maintenance fertilization is to maintain a given level of a nutrient in the soil. Almost all soils that test higher than the indicated minimum can be maintained at this level by adding enough fertilizer to replace the nutrients removed by crops. The amount may need to be modified slightly with differences in leaching losses or weathering. Soils testing below minimum levels for maintenance will need more fertilizer than is removed by the crop to give optimum yields.

Thus soils that are naturally at, or have been built up to, the 90 percent level are best suited to a maintenance program. On soils testing higher than the indicated minimum, maintenance of test levels will require more fertilizer than is needed for optimum yields.

The table on the next page gives the quantities of phosphate fertilizers needed to maintain yield and soil nutrient levels under average conditions. Yield can be maintained temporarily with much less fertilizer than is needed to maintain nutrient levels.

Phosphorus Maintenance Requirements

Soil test level	Superphosphate program: Maintenance of nutrient level 4-year rotation 0-20-0	Superphosphate program: Maintenance of yield level 4-year rotation 0-20-0	Rock phosphate program: Maintenance of nutrient level 6- to 8-year requirement rock phos.	Rock phosphate program: Maintenance of yield level 800 of rock plus extra soluble phos. 0-20-0
	lb./A.	lb./A.	lb./A.	lb./A. yearly
S+	600 1/	600 1/	800 2/	75
M-	600	600	800	75
M	600	300	800	Starter
M+	600	300	800	Starter
H-	600	Starter	800	Starter
H	600	Starter	800	Starter
H+	600	Starter	800	Starter

1/ These quantities are equivalent to crop removals for average 4-year rotations at the 100-bushel corn level.

2/ These quantities are equivalent to crop removals for average rotations for an 8-year period.

To maintain yield at various potassium test levels, it is necessary first to distinguish between soils that have a large amount of the "storehouse" form of potassium and those that contain little of this form. Because some of the added potassium will go into the "storehouse" form (see SF-2) and the soil tests do not measure this form, there is no accurate way to determine how much potash fertilizers are needed to maintain test levels. For potassium, therefore, only yield maintenance is considered. The following table may be used as a guide in determining potash maintenance needs for Illinois soils:

Potash Maintenance Requirements

Soil test level (lb./A.)	Percent of 4-year rotation crop removal: Northern Illinois	Percent of 4-year rotation crop removal: Southern Illinois
120 to 150	100	Build-up
150 to 170	75	100
170 to 190	50	75
190 to 210	Starter	50
210 and over	Starter	Starter

The table below assumes levels for conditions of equilibrium; that is, they are not temporary as the result of a large application of potash the year before the sample was taken. Soils should be retested every 6 to 8 years to check their reaction to treatment.

The concept of maintenance fertilization is not the same for nitrogen as for phosphorus and potassium. A level of soil nitrates or ammonia that will produce optimum yields cannot be maintained over any length of time. Nor is it possible to maintain a level of organic matter

high enough to furnish enough nitrogen to give optimum yields.

Actually, since some crops, like legumes and soybeans, can fix part of the nitrogen they need, it is not desirable to maintain very high nitrogen levels. In the use of fertilizer for nitrogen maintenance, therefore, the object is to supply the soil with just enough to produce high yields with little or no loss of nitrates due to leaching or with no reduction in soil organic matter.

The program of nitrogen maintenance fertilization is essentially one of estimating the needs of the expected crop and then applying the needed amount before or as the crop is grown. The nitrogen need is determined by calculating the crop requirement--essentially the amount removed by the crop--and subtracting the estimated amount plowed-under legumes or residues may be able to furnish. The difference is the amount that must be supplied to produce the expected yield.

Corrections must be made for soils that are subject to severe leaching of nitrates. For most soils, except sands, peat, or soils that are subject to excessive leaching, use of crop-removal quantities of nitrogen will about maintain the soil organic matter level. In general nitrogen leaching is not serious on Illinois soils (see SF-4).

Soluble mixed fertilizers are usually best for maintaining soil fertility, with the extra nitrogen need supplied as a straight carrier. Manure may be used as part of the maintenance fertilizer; its value will depend solely on its nutrient content.

Plowed-under legumes will furnish nitrogen and may be considered a straight carrier. In a maintenance program, not more than half of the total nitrogen in the legume may be considered new nitrogen, however. For practical purposes, each ton of the legume plowed under may be expected to furnish about 20 pounds of nitrogen per acre. Plowing-down legumes does not add any new potassium or phosphorus to the soil.

Maintenance fertilizers are usually most effective when applied as starter fertilizers for crops that have high fertility requirements, with the extra nitrogen plowed under or side-dressed after the crop is up. In a maintenance program the soil should be retested every 6 to 8 years to check the adequacy of the fertilizers that have been used.

Obviously the highest testing soils that receive less nutrients in fertilizer than the crops remove will sometime drop to lower test levels. Since weathering cannot be stopped, it becomes sound practice on these high-testing soils to take advantage of, and use, the nutrients that become available each year from the unavailable forms. The retesting program will permit modification of maintenance needs to meet changing soil conditions.

S. W. Melsted
11-9-53

PRINCIPLES OF TESTING FOR AVAILABLE SOIL PHOSPHORUS

There are two groups or forms of soil phosphorus that contribute significantly to crop growth. These are the "acid-soluble" or calcium forms and the adsorbed or exchangeable forms. Both should be measured as a basis for making fertilizer recommendations (see Agronomy Facts sheet SF-3). Corn-belt soils contain both kinds, naturally as well as from the additions of rock and soluble phosphates.

The more acid soils usually have a higher proportion in the adsorbed forms. The less acid to neutral soils usually have a higher proportion (naturally occurring) in the acid-soluble forms. Almost 25 percent of the dark-colored prairie soils naturally tested "high" in acid-soluble forms around 1930. Since then hundreds of thousands of acres have been treated with rock phosphate, also an acid-soluble form. Few of these soils test high naturally as a result of adsorbed forms, and not enough soluble phosphates have beed added to create a "high" test for adsorbed forms.

A soil testing medium to high in the adsorbed forms is more effective than one containing high amounts of the acid-soluble forms. The latter forms have a limited effectiveness in that, to obtain maximum yields of some crops, some soluble phosphate must be added as a starter. Wheat, following soybeans, may be as much as 10 bushels short in yield unless soluble phosphate is drilled with the seed, even though 4 tons of rock phosphate per acre have already been added.

The P_2 test was designed to extract both forms of available phosphorus. It consists of 0.10 normal hydrochloric acid in 0.03 normal ammonium fluoride. The acid dissolves the acid-soluble forms, including rock phosphate. The fluoride ion displaces adsorbed forms. The test extracts about one-third of the total, probably the more available one-third.

A high P_2 test may be due to high amounts of the acid-soluble forms, to high amounts of the adsorbed forms, or to a combination of both forms. Thus, medium to high test values do not indicate whether or not a starter is needed. The P_1 test was designed to distinguish between these situations. It is a solution of 0.025 normal hydrochloric acid in 0.03 normal ammonium fluoride. The small amount of acid is buffered by the exchangeable bases; the fluoride displaces the adsorbed phosphates. No factor has been worked out to determine the proportion of adsorbed forms removed. Generally, it is only the soils that have been treated with soluble phosphate that test high by the P_1 test.

A soil that tests low by the P_2 test will always test as low or lower by the P_1 test, showing a need for large amounts of phosphate fertilizers. A soil that tests high by the P_2 test will also test high by the P_1 test, provided the result is due to adsorbed phosphates, and no phosphate is needed. But when a high P_2 test is due mainly to the acid-soluble forms, the P_1 test will be low and only starter soluble fertilizer will be needed. The table illustrates these situations with experimental field data.

In the Illinois soil testing program, only the P_2 test is used because of the scarcity of soils testing high mainly because of adsorbed forms. The record of previous treatments should show which forms of fertilizers have been added. In the absence of records, a high P_2 test

(Continued on other side)

is assumed to be due to acid-soluble forms, either naturally present or resulting from added rock phosphate, and starter soluble phosphate should be used on those crops that require it. Low P_2 tests indicate the need for general use of relatively large amounts of phosphate fertilizers.

It is probable that as the use of soluble phosphates increases and the adsorbed forms are built up, and as treatment records become lost or confused, the use of both P_1 and P_2 tests on each sample may become standard practice.

Using a Test That Measures Only the Adsorbed Forms of Phosphorus

Recently several soil chemists have suggested that only the adsorbed forms of phosphorus be measured as a guide to fertilizer use. Both the P_1 solution and an alkaline solution of sodium bicarbonate have been suggested for this purpose.

Where the adsorbed forms are dominant and the acid-soluble forms are present in only negligible amounts, this procedure might be feasible. For calcareous soils, where it is difficult to evaluate the acid-soluble forms, it might be justified as an expedient. But to recommend either of these tests as a general test for calcareous, neutral, and acid soils, without qualification, is to ignore the fact that many crops can approach, if not achieve, their maximum yields when only the acid-soluble forms are present in significant amounts.

Such a procedure could not distinguish between soils needing only a small amount of starter soluble phosphate and ones needing the general use of large amounts of phosphorus. It could lead to the use of large amounts of fertilizers where only small amounts are needed.

In contrast, the P_2 test used without the P_1 test may indicate the need for small amounts of fertilizer where none is needed. But it will not indicate the need for large amounts where only small amounts are needed. It is because the acid-soluble forms contribute significantly to crop growth in corn-belt soils that neither the P_1 nor the alkaline sodium bicarbonate test is recommended for general use as the only guide for phosphorus fertilizer recommendations.

The table below illustrates the fact that the P_1 test for adsorbed phosphorus does not distinguish between high, medium, low, and starter needs.

Phosphate Needs and the P_1 and P_2 Test Values

Experiment field	Limed plots P_1	Limed plots P_2	Relative need for phosphorus
	lb./2 M of soil		
Enfield	14	16	High
Raleigh	15	15	High
Carlinville	20	31	High
Joliet	21	31	High
Clayton	21	54	Medium
Hartsburg	22	62	Low
Minonk	26	71	Low
Clayton + rP	22	200+	Starter only
Des Plaines + sP	177	200+	None

Roger H. Bray
12-21-53

AGRONOMY FACTS

METHODS FOR DETERMINING NITROGEN REQUIREMENTS

Successful tests have been developed for determining the available phosphorus and potassium in soils. Why do we not have tests for available nitrogen? The problem is different for nitrogen than for phosphorus and potassium for this reason.

The available forms of phosphorus and potassium, as well as nitrogen, are all inorganic (SF2, 3, and 4). Soils may contain from four to ten times as much available phosphorus and potassium as a single crop will remove. The unused portion remains in the soil, ready for the next crop. A test for phosphorus or potassium therefore involves merely extracting more or less proportionate amounts of the available forms, measuring them, and calibrating the plant response.

Organic nitrogen, on the other hand, is not available per se to plants (SF-4). It is stored in the soil organic matter and is slowly converted to available ammonium and nitrate-nitrogen forms by microbes throughout the growing season.

Phosphorus and potassium do not depend entirely on microbial activity to change them into forms available for plant use. Nitrogen does. Differences in environmental factors affect the amount of microbial activity and, in turn, the amount of organic nitrogen that is changed to available form. For this reason it would be very misleading merely to extract and measure the present amount of available nitrogen, as is done for phosphorus and potassium, before planting a crop in order to determine how much nitrogen would be available to future crops.

The fact that the degree of microbial activity can not be determined in advance is the basis for skepticism regarding the value of existing tests for determining available nitrogen and for failure to recommend them not only in Illinois, but also in many other states.

Several methods for estimating soil nitrogen requirements are, however, in use or have been proposed. They can be grouped as follows: (1) predictions based on previous yields and cropping history, (2) laboratory chemical tests, (3) laboratory incubation of soils, and (4) deficiency symptoms and plant analysis.

Previous yields and cropping history. Reliable information about the probability of nitrogen response following certain crop sequences has been obtained from field experiments conducted over a period of years (AG1-86). These data are used in making nitrogen recommendations in Illinois (AG1588) and many other states.

This approach is not infallible. To be effective, it requires careful analysis of certain factors: First, one must know the nature of the rotational nitrogen fertility pattern in order to understand where in a rotation nitrogen response is probable (p. 38, AG1589). Second, one must recognize the need for adequate minerals in getting efficient nitrogen response (p. 9, AG1-86).

After consideration of these two factors comes the question of population, particularly with corn, and other management factors. If after all factors are considered, it appears that nitrogen response is probable, the expected yield increase for corn is multiplied by an efficiency factor of 2 or 3--the number of pounds of nitrogen required to produce an increase of one bushel. For example, if past yields have averaged 50 bushels, and 80 bushels is the goal, to secure this 30-bushel increase would require 60 to 90 pounds of nitrogen an acre, assuming that the population is also adequate.

The efficiency factor of 2 to 3 pounds of nitrogen per bushel of corn is not unchanging. At high yield levels it may be considerably greater (e.g., 5 to 7). But in a yield range of 40 to 75 bushels, with adequate populations, average weather and management, etc., it can be expected to be in the range of 2 or 3 for corn.

Laboratory chemical tests. Numerous laboratory investigations have shown that the amount of nitrogen released by a soil is related to the amount of organic matter in that soil. Field experiments on limited soil areas have shown that crop yields tend to be correlated with soil organic matter levels. Long-term field experiments also show that 2 or 3 percent of the total organic matter in well drained heavy to medium textured and sandy soils decays with the release of proportionate amounts of available nitrogen (p. 38, AG1589). In spite of this evidence, nitrogen recommendations based solely on organic matter determinations are not reliable.

Actually, the nature of the residues incorporated into soils is more important in determining the amount of available nitrogen than is total organic matter content (AG1589). In Missouri, soil organic matter determinations are part of the soil-testing program. But nitrogen recommendations are not based solely on this determination. The net contributions and effects of incorporated residues are also carefully considered. In Illinois, satisfactory nitrogen recommendations are made from past yields and cropping sequences which in themselves reflect organic matter levels and activity.

Wisconsin has developed a laboratory soil nitrogen test that has not been tested for reliability in other states. This method differs from the regular total organic matter method in that the more loosely held nitrogen is split off from

the organic matter as ammonia and the amount is determined. It, however, would seem to have many of the limitations of the organic matter determinations. For example, from the test results it is not possible to predict the effects of residues, particularly those of wide carbon-nitrogen ratios, on net nitrogen availability. Again it would seem to be necessary to consider past yields and cropping sequence in arriving at a satisfactory recommendation.

Laboratory incubation methods. Incubation of soils under standard laboratory temperatures and moisture conditions represents one of the first attempts to assess nitrogen fertility. Theoretically this approach is sound. Activity of the microbes that naturally release available nitrogen determines nitrogen fertility. But release of nitrogen under laboratory conditions can be quite different from that occurring under field conditions, where both temperature and moisture may vary. As these limitations became apparent, interest in microbial methods naturally declined.

In the past few years, however, workers at the Iowa Experiment Station have reactivated interest in the microbiological approach. A major objection to the method had been the 30-day incubation period. Iowa has been able to cut this time to 14 days, which is comparable with the 10-day drying interval required for the potassium test.

Iowa workers have also not overlooked the importance of unincorporated residues and stand on the reliability of nitrogen recommendations. They report greater reliability in predicting nitrogen needs of second-year corn than of first year, as might be expected because of differences in managing legume and grass stands.

The Iowa results look promising. If the method should prove applicable, it will not be particularly adapted for county testing laboratories. The microbiological test would need to be run in adequately equipped and staffed central laboratories. Interpretation of results would require a knowledge of past yields and cropping history and exercise of good judgment.

Deficiency symptoms and plant tests. So far we have talked about methods of estimating nitrogen needs prior to seeding. Obviously deficiency symptoms and plant tissue tests cannot be used for this purpose. They do, however, serve as valuable aids in determining nitrogen deficiencies and the adequacy of nitrogen fertilization programs arrived at by other methods.

In corn the main symptom of nitrogen deficiency is yellowing of the lower leaves from the tip back through the midrib section. Unless the deficiency is severe, symptoms do not appear until just before or after shooting, and then it is too late to correct. They are, however, useful in pointing out the need for nitrogen fertilizers. The U.S.D.A. reports that, for each nitrogen deficient leaf at shooting stage, corn yields are decreased 15 bushels an acre, assuming that all plants show deficiency symptoms.

Hidden nitrogen starvation, in which no deficiency symptoms are apparent, is common in Illinois. The best way to detect it is by plant analyses or tissue tests, which determine the amount of nonassimilated nitrate nitrogen in the plant. A positive test indicates sufficient nitrogen; a negative test indicates a deficiency.

Nonassimilated nitrate nitrogen may or may not indicate sufficient nitrogen. For example, free nitrate may accumulate when potassium or some other essential element or growth factor is limiting plant growth. For this reason nitrogen tests should always be accompanied by tissue tests for phosphorus and potassium.

Nitrate nitrogen tends to disappear as plants mature. An early tissue test may indicate a sufficiency; a later test may show nitrogen starvation. For this reason tissue tests should be made at various stages of growth. To obtain maximum yields, assuming adequate minerals, the tests should show positive until the moisture content of ear corn is about 50 percent.

In conclusion, the dependence of nitrogen availability on microbial activity makes testing for available nitrogen a more difficult problem than testing for available phosphorus and potassium. The probable response of grain crops to nitrogen fertilizers can be determined only by taking into account previous yields and cropping history, kinds of residues returned to the soil, and adequacy of natural or applied phosphorus and potassium fertility. Tests for available nitrogen can serve only as partial guides. In the final analysis considerable attention must be given to all of the aforementioned factors in translating the results of a nitrogen test into specific nitrogen recommendations.

Edward H. Tyner
1-4-54

AGRONOMY FACTS

SF-18

ROTATIONS

Determining, establishing, and maintaining suitable cropping sequences on farm lands is not easy. Sequences are affected by such factors as land suitability, land use, economies, labor, continuity of management, potential of applied productivity, and many hazards. Also some of the factors that cause conflicts frequently have changing impacts. So it is not surprising that interpretations and use of sequences often do not agree among individuals whose desires, needs, objectives, abilities, and points of view differ. Even the conditions of the individual change frequently. Standard patterns and proportional units need to be established for each specific situation.

Table 1 gives factual data from rotation experiments showing the use of land and the consequences of such use. These data can be interpreted in several ways. Since first-year corn is common to all systems, it can be used as a comparative measure of the effect of the system on productivity of the soil. From this viewpoint, systems with standover legumes have been superior to those with catch crops. Systems with catch-crop

Table 1.--Effect of Cropping Sequence on Crop Yields - Drummer Clay Loam Department of Agronomy - South Farm, Urbana, Illinois

Location	Rotation[a]	Mean acre yield 1940-1951: 1st. yr. corn	2nd. yr. corn	Beans	Wheat	Oats	Hay	Average current values 1948-51
		bu.	bu.	bu.	bu.	bu.	tons	
	1-C-O[c]	86[b]				53		$ 81.18
M-9	2-C-W[c]	86[b]			23			93.02
500 - 600	3-C-B	74		28				91.19
	4-C-O	72				49		64.76
	5-C-W-Cl(alf.)	90			30		2.44	84.52
M-19	6-C-C-W[c]	83	68		26			92.72
500 - 700	7-C-O-W[c]	83			31	56		73.84
	8-C-O-W	72[b]			29	52		63.73
	9-C-B-W-Cl	93[b]		33	29		1.04	76.45
M-19	10-C-O-Cl-W[c]	87			37	61	1.51	69.20
100 - 400	11-C-C-B-W[c]	86	78	34	27			95.79
	12-C-B-O[c]/W[c]	85		33	32	63		79.05
	13-C-C-O[c]/W[c]	83	76		33	61		85.33

a/ All plots treated uniformly with limestone, phosphate, and potash. The average organic matter content is 5.5 percent.

b/ Rotations 1 and 2 significantly higher than 3 and 4. Rotation 8 significantly lower than 5, 6, and 7. Rotation 9 significantly higher than 10, 11, 12, and 13.

c/ Green manure catch crop.

legumes have been superior to those without catch crops. In no case where second-year corn occurs did the system maintain as high a yield for second-year corn as for first. Whether this was due entirely to nutrient supply or physical breakdown has not been determined. Soybeans have not been significantly affected by sequences.

Clover seems to be the best crop to precede wheat, and corn the poorest. Oats and soybeans are intermediate. What, if any, treatment practice might improve this relationship has not been determined. Oats have fared better with each additional crop added to the sequence.

Hay production on the plots has been poor because of the hazards associated with isolated production on small areas. This seemingly has interfered with realizing benefits that would normally be expected.

Organic matter and aggregate stability are physical properties of soil that can be measured as an effect of crop production. Preliminary studies of these properties indicate that the soil is naturally high in organic matter (average 5.5 percent), and during the short period of this experiment this level has not been changed by the cropping systems used. Aggregate stability findings thus far indicate that standover legumes have been significantly better in maintaining stability than catch-crop legumes and that likewise catch-crop systems are superior to no catch crop.

Annual current crop prices, averaged for the years 1948-51 inclusive in the last column of Table 1, show the gross annual acre returns for each system. When these figures are compared with those of first-year corn, the conflict between cash income and soil productivity maintenance is evident.

Table 2.--Effect of Various Forage Crops and Hay Removal on Crop Yields

Area	Forage	No. of hay crops removed	Corn	Oats	Wheat	Hay
			bu.	bu.	bu.	tons
M-9	Red clover	0	93	70	34	....
	Red clover	1	89	66	32	1.37
Series	Red clover	2	87	68	31	2.48
100 -	Alfalfa	2	89	64	34	1.87
400	Sweet clover	0	92	64	33	....
	Timothy	1	76a/	58	28	1.17

a/ Significantly lower than other yields.

Studies comparing various forage crops and the management of the growth are given in Table 2.

Corn following timothy (a grass crop) is significantly lower in yield than corn following legumes.

In this study there has been no significant difference between red clover, alfalfa, and sweet clover as standover legume crops. Likewise, there has been no significant difference whether no, one, or two crops of red clover have been removed. However, the trend of all crops favors plowing all the growth down. In time this difference may become greater. It is also reasonable that there would be greater differences on soils of lower native productivity and organic matter than on the better soils.

A. L. Lang
2-15-54

AGRONOMY FACTS

SF-19

THE NATURE OF RESERVE AND ACTIVE SOIL ACIDITY

Soil acidity is due to exchangeable hydrogen on soil colloidal surfaces (SF-1). In crop production two types of acidity are of practical interest, namely, reserve and active acidity. An important difference between reserve and active acidity lies in the location of the acid-producing hydrogens. This difference is illustrated in Diagram A.

$$\text{(A)}\qquad \begin{array}{ccc} & \text{H H H} & \\ \text{H} & \boxed{\text{Soil Colloid}} & \text{H} \\ & \text{H H H} & \end{array} \rightleftharpoons H^+ \text{ (in solution)}$$

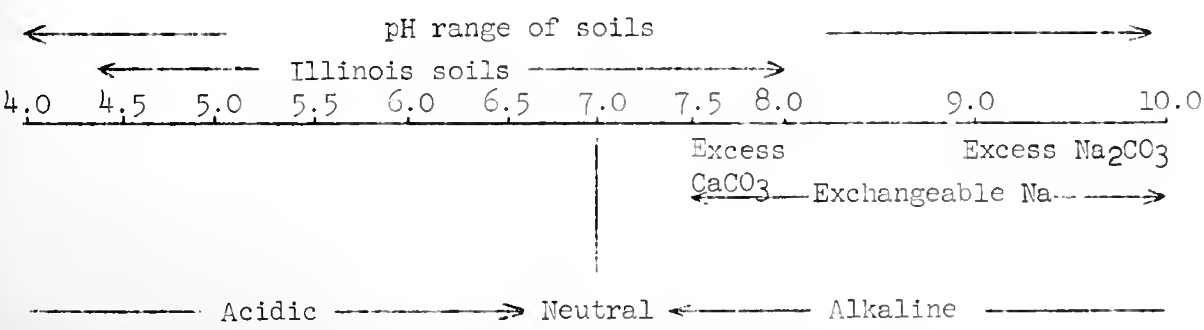
Exchangeable H (Reserve acidity) — Hydrogen-ion (Active acidity)

The rather firmly held exchangeable hydrogen on colloidal surfaces represents the reserve soil acidity. Note that for each active H-ion in solution there are numerous reserve exchangeable hydrogens still attached to the surface, and the reserve hydrogen and active hydrogen tend to be in equilibrium. The lime requirement of a soil quantitatively indicates its reserve acidity.

The ionization of exchangeable hydrogen gives rise to free hydrogen ions in the solutions bathing the colloidal surfaces. The free hydrogen ions represent active acidity. The concentration of active acidity or free hydrogen ions in solution is universally expressed in pH units. Microbiological activity, plant nutrient availability, rock phosphate solubility, and numerous other factors affecting plant growth are closely related to the free, active hydrogen-ion concentration or pH of soils.

Pure water has a pH of 7. This value represents neutrality. A pH of less than 7 is in the acidic range. A pH greater than 7 is in the alkaline range. The pH range for soils may vary from about 4 to 10. If the acidity of a soil is less than 4, it is quite probable that a free, strong acid, for example, sulfuric, is present. The low pH values (2.3-2.5) found on strip-mine spoils and near smelters is due to free sulfuric acid or iron and aluminum sulphate produced by the acid.

Soils containing considerable amounts of free excess calcium carbonate or exchangeable sodium (shelly spots, marl, slick spots) have pH values of about 7.5-8.0. Very strongly alkaline soils (pH 9 to 10) usually contain sodium carbonate or very large amounts of exchangeable sodium. These general relations are diagrammatically illustrated below.



Exchangeable calcium, magnesium, potassium, and sodium are also present on soil colloidal surfaces. These elements impart alkalinity, in contrast to exchangeable hydrogen, which imparts acidity. This is illustrated below in Diagram B.

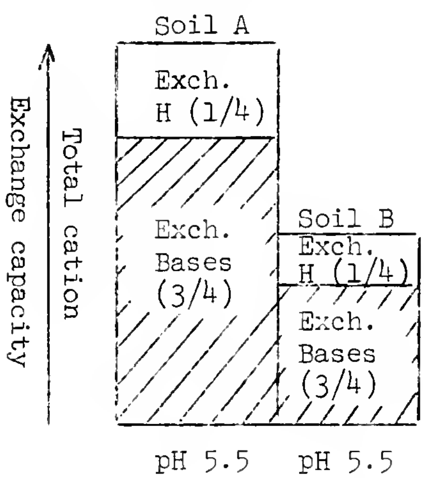
(Neutral to alkaline-
base saturated)

(Acidic)

The total number of reactive spots on the soil colloidal surface where exchangeable calcium, magnesium, potassium, sodium, and hydrogen cations can be held is more or less constant for a given soil. The capacity of soils to retain exchangeable cations (Ca, Mg, K, H, and Na) is termed cation exchange capacity.

The cation exchange capacity, however, can vary for different soils depending upon their humus and clay content and the type of clay present. Thus sandy soils, because of their lower clay and humus, have fewer reactive spots where exchangeable cation can be held and, accordingly, lower cation exchange capacities than heavy-textured soils.

The average soil has exchangeable Ca, Mg, K, and H absorbed on its colloidal surfaces. From Diagram B it is obvious that their effects on soil acidity are different. It is the ratio of the sum of the exchangeable bases to exchangeable hydrogen, therefore, rather than the total amount of exchangeable hydrogen, that determines the pH of soils. This principle can be illustrated by considering the examples of Soils A and B illustrated below:



The exchange capacity of A is twice that of B. The ratio of exchangeable hydrogen to exchangeable bases, however, is identical for both A and B, namely, 1/4 hydrogen and 3/4 bases. The percent of the cation exchange capacity or reacting spots satisfied by exchangeable bases, or the degree of base saturation, is identical for both A and B. Soils A and B therefore have identical pH values, since the pH of a soil is more or less dependent on the degree of saturation. The approximate relation of degree of base saturation to pH values for Illinois soils is given in the following table:

Percent of base saturation	Corresponding pH
95	6.5-7.0
90-95	6.2-6.4
85-90	5.8-6.1
75-85	5.7-5.4
50-75	5.3-4.8
25-50	4.7-4.2
< 25	4.0

In the preceding diagram, the active acidity, or pH, of Soils A and B was identical because of similar degrees of saturation. Note, however, from the thickness of the bar (Exch. H) that the <u>reserve acidity</u> of Soil A is twice that of Soil B. Lime reduces the reserve acidity. Since the reserve acidity of A is twice that of B, Soil A will need to have twice as much lime applied to it as Soil B will in order to get a similar shift in pH values. Differences in base exchange capacity and reserve acidity are the reasons why more lime is needed to correct acidity on heavy-textured soils than on sandy soils.

When lime is added to soils, the reserve exchangeable hydrogens are replaced by calcium. The degree of saturation, or the ratio of the exchangeable bases to exchangeable hydrogen, is increased and the soil pH shifts in the direction of neutrality. This process is diagrammatically illustrated below:

75% Base Saturation	25% Exch. H	+ $CaCO_3$ →	95% Base Saturation		+ CO_2 + H_2O
pH 5.5			pH 7.0		

An effective neutralizing agent not only must replace the exchangeable hydrogen on soil surfaces, but must also deactivate the replaced hydrogen ion, converting it to a relatively inert product which on ionization gives fewer hydrogen ions than previously existed on the soil surfaces. This requisite is fulfilled in the preceding diagram, where the exchangeable hydrogen, through reaction with lime, gives rise to a neutral product--water.

Such substances as gypsum ($CaSO_4.2H_2O$) supply calcium but will not neutralize soil acidity because the replaceable hydrogen is not converted to an inert or neutral product. This process is illustrated below:

$$\overset{\text{H H H}}{\underset{\text{H H H}}{\text{Soil Colloid}}} + 3\,CaSO_4 \longleftarrow \overset{\text{Ca}}{\underset{\text{Ca}}{\text{Soil Colloid}}}\ Ca + 3H_2SO_4$$

In the above illustration the exchangeable hydrogen is replaced and forms sulfuric acid. The sulfuric acid produced in this reaction is a <u>much stronger</u> acid than the acid produced when the hydrogen exists in exchange form on the soil colloidal surfaces. Any tendency for the reaction to move toward the right, in the direction of neutrality, is immediately counteracted by the strong production of sulfuric acid, which drives the reaction back to the left, or its original state. The result is that no neutralization can occur because no permanent shift in degree of saturation is possible.

To summarize: The soil colloidal fraction is the seat of permanent soil acidity. The primary difference between reserve and active acidity lies in the location of the acid-producing hydrogens. The lime requirement is a measure of reserve acidity. The concentration of active acidity is reported as pH. Liming controls active acidity, as the lime that is added causes shifts in the degree of saturation. Only those substances that react with soils to effect real changes in degree of saturation are suitable for liming purposes.

Edward H. Tyner
2-22-54

THE MINOR ELEMENT PROBLEM IN ILLINOIS SOILS

The minor or trace elements boron, copper, zinc, manganese, iron, and molybdenum are all needed for plant growth. Calcium, magnesium, and sulfur, while usually regarded as major elements, are also essential to plant growth and will therefore be included here. Cobalt, a nutrient required for animal growth, will also be considered.

Information on the minor or trace elements in Illinois soils is somewhat incomplete, but certain general facts are known. A summary of this information is presented briefly here.

Boron. Illinois soils, generally speaking, are all low in boron (see SF-12). This deficiency is most noticeable in alfalfa and clovers and has been observed in all of the major soil types of the state. Boron is usually recommended for all new legume seedings. Boron deficiencies have never been observed in any of the grain crops in Illinois.

Copper. There are no known areas in Illinois where the soils are deficient in copper for agronomic crops. Analyses show that most of the soils in the state contain from 10 to 20 pounds of available copper per acre. On none of the major soil types where copper fertilizers have been used have yields of agronomic crops increased because of the treatments.

Zinc. Like copper, no areas of zinc-deficient soils for agronomic crops have yet been found in Illinois. Our soils seem to be high in this element, usually containing from 10 to 30 pounds of available zinc per acre. Where zinc fertilizers have been used, none of the major soil types of the state have shown yield increases in agronomic crops for such treatments.

Manganese. The only part of the state where manganese may be deficient is in the Kankakee sand area. However, no manganese deficiencies in agronomic crops have been observed in this area, and crops have not responded to manganese fertilizers. In many areas, especially in the older and more weathered soils of the southern half of the state, manganese is actually present in quantities high enough (200 pounds of available Mn per acre) to be toxic to agronomic crops. Liming such soils usually reduces the amount of available manganese to such extent that toxic conditions no longer exist.

Iron. Iron is not deficient for agronomic crops in any Illinois soil.

Molybdenum. Preliminary surveys have not shown any indications of molybdenum deficiencies for agronomic crops grown on any major soil type.

Cobalt. Cobalt is not known to be essential for plant growth. Therefore no cobalt-deficient areas exist so far as the production of agronomic crops is concerned. Chemical analyses of agronomic plants grown on Illinois soils, however, show that the cobalt level is approaching the critical minimum usually assumed to be required in plants for animal needs. Therefore, a cobalt deficiency in livestock is not impossible under Illinois conditions.

Minor Element Fertilizer Recommendations

Minor element fertilizers, with the exception of borax, are not recommended for Illinois soils for the production of agronomic crops.

Calcium. Calcium deficiencies have been found in southern Illinois on the older weathered soils. When soils are limed for agronomic crops, no soil in Illinois will be deficient in calcium.

Magnesium. Magnesium deficiencies have been observed in the Kankakee sand area and in southern Illinois on the older weathered soils. Deficiencies may be expected to occur in the sand areas and the older soils of the state. Need for magnesium fertilizer can be determined by testing. Test your soils before buying magnesium fertilizers. The use of some dolomitic limestone in the regular liming program is recommended for southern Illinois and the sand areas of the state.

Sulfur. Soils deficient in sulfur for agronomic crops have not been found in Illinois. Usually normal rainfall, as well as commercial fertilizers, contain more sulfur than is required for agronomic crops.

S. W. Melsted
3-1-54

AGRONOMY FACTS

SF-21

CORN YIELDS - ILLINOIS SOIL EXPERIMENT FIELDS

8-Year Average, 1946-1953

Field location			1	2	3	4	5	6	7	8	9
Town	County	Rotation[1/]	O	M	ML	MLP	O	R	RL	RLP	RLPK
		Dark-colored soils - first-year corn									
			bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.
Aledo	Mercer	C-C-O-H	78	96	102	105	52	58	77	78	80
Carlinville	Macoupin	C-B-W-H	49	81	100	102	55	58	80	88	101
Carthage	Hancock	C-B-W-H	68	92	100	100	74	81	98	94	100
Clayton	Adams	C-B-O-H	53	80	88	91	47	57	73	83	86
Dixon	Lee	C-O-Cl-W	58	94	103	105	63	74	87	91	100
Hartsburg	Logan	C-C-O-H	76	98	101	99	56	78	90	93	90
Joliet	Will	C-B-C-O-W-H	41	60	65	79	43	47	56	81	86
Kewanee[2/]	Henry	C-C-O-H	60	77	86	92	71	79	93	95	97
Lebanon	St. Clair	C-B-W-H	36	92	104	107	47	52	91	91	100
McNabb	Putnam	C-C-O-H	97	112	110	112	50	101	105	106	...
Minonk	Woodford	C-C-O-H	87	95	95	96	57	78	82	88	87
Mt. Morris[2/]	Ogle	C-C-O-H	64	86	98	97	58	69	95	99	102
Average			64	89	96	99	56	69	86	91	94
		Dark-colored soils - second-year corn									
Aledo	Mercer	C-C-O-H	73	96	102	99	57	59	65	72	73
Hartsburg	Logan	C-C-O-H	73	98	99	98	54	65	69	72	72
Joliet	Will	C-B-C-O-W-H	36	65	72	77	35	39	48	62	73
Kewanee	Henry	C-C-O-H	61	86	95	95	..	..	..	..	..
McNabb	Putnam	C-C-O-H	78	107	108	111	53	90	82	91	..
Minonk	Woodford	C-C-O-H	74	88	85	83	52	59	60	64	66
Mt. Morris	Ogle	C-C-O-H	53	97	105	101	..	..	..	..	..
Average			64	91	95	95	50	62	65	72	71
		Light-colored soils - prairie									
Brownstown	Fayette	C-B-W-H	24	46	67	..	29	33	47	54	73
Ewing	Franklin	C-B-W-H	11	39	64	66	18	29	38	43	78
Newton	Jasper	C-B-W-H	6	31	75	80	15	18	43	47	64
Oblong	Crawford	C-B-W-H	21	50	84	88	27	34	58	61	92
Toledo	Cumberland	C-B-W-H	15	52	75	74	16	23	41	37	81
Average			15	44	73	77	21	27	45	48	78

1/ The rotation on plots 5-9 is C-C-O-W at Aledo, Hartsburg, McNabb and Minonk; at Kewanee and Mt. Morris these plots have a C-O-W-H rotation.

2/ Yields are 4-year averages (1950-1953) because of recent rotation change.

(Continued on other side)

8-Year Average, 1946-1953 (Cont.)

Field location		Rotation	1	2	3	4	5	6	7	8	9
Town	County		0	M	ML	MLP	0	R	RL	RLP	RLPK
		Light-colored soils - timber									
			bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.
Enfield	White	C-O3/-W-H	10	35	57	56	14	18	37	41	58
Raleigh	Saline	C-O-H-W	7	26	52	50	14	18	38	40	59
Sparta	Randolph	C-O3/-W-H	8	21	62	63	3	8	40	37	65
Average			8	27	57	56	10	15	38	39	61
		Hilly land - southern Illinois									
Elizabethtown	Hardin	C-O3/-H-W	..	39	55	58	13	14	40	49	57
		Sandy land - western Illinois									
Oquawka	Henderson	C-B-W-H	..	51	65	64	37	43	52	52	62

3/ Winter oats.

The reported corn yields are for the 8 years from 1946 to 1953 on variously treated plots on 22 Illinois soil experiment fields well distributed over the state.

The indicated crop rotations are in use at the present time. On most of the older fields the cropping system has been changed at least once since the fields were established.

Soil treatment in the livestock system (plots 1-4) includes barnyard manure (M) used alone, with limestone (ML), and with limestone and phosphate (MLP). In the grain system (plots 5-9) crop residues (R) are used alone; with limestone (RL); with limestone and phosphate (RLP); and with limestone, phosphate, and potash (RLPK). A check or untreated plot is included in each system. On several of the fields the rotation used in the grain system is different from that used in the livestock system, as shown in footnote 1.

A detailed explanation of the treatments and rotations and a description of the soil types will be found in Illinois Bulletin 516, "Effect of Soil Treatment on Soil Productivity."

These average yields were produced with bulk applications of limestone, rock phosphate, and muriate of potash (on respective plots) used in the rotations as described. On many of the fields additional tests have been made with starter fertilizers, superphosphate, mixed fertilizers, and nitrogen used in various ways. Mimeographed pamphlets are available for each field giving yields and values of all crops and amount and costs of soil treatments under several systems of management.

Soil Experiment Field Staff
L. B. Miller
3-8-54

WIDE-ROW SPACING OF CORN

One possibility of planting corn in wide rows is to use the corn as a nurse crop for legumes or grasses in establishing pastures or stand-over sods. Trials with wide-row spacings of corn without sod seedings have been carried out by several experiment stations. But very little work has been done on the cultural practices required for legume and grass seedings when corn is used as the nurse crop. The practice of using corn in wide rows as a nurse crop is new, and the available information is therefore fragmentary.

Trials show that spacing corn in rows up to 60 inches with constant seeding rates does not materially affect yield. As the width between rows increases, however, the number of stalks in the row must increase. Generally, when corn is seeded in 80-inch rows yield has decreased slightly.

Preliminary trials with corn as a nurse crop show that the stands of legumes or grasses improve progressively as the corn row spacings are increased from 40 to 80 inches. The wider spacings, 60 to 80 inches, permit small tractors and equipment to operate between the rows to prepare seedbeds and seed the legume or grass crops. With proper seedbed preparation good stands of legumes and grasses have been obtained. The best legume and grass stands have usually come from spring plantings. Rye or ryegrass is usually seeded in early September, when only late fall and early spring pastures are desired or when the primary objective of the grass seeding is to control erosion.

Corn seeded in 60- to 80-inch rows has several advantages over the small grains as a nurse crop:

1. Corn is worth more than the small grains.
2. The legume or grass sods act as a cover crop for the corn and therefore help to control erosion in the cornfields.
3. When small grains are used, the heavy straw residues from the grain harvest may smother the legume or grass.
4. Heavy fertilization of the nurse crop will not retard the legume or grass stands.
5. With corn as the nurse crop, the farmer can carry on an intensive corn-legume-livestock rotation on his farm.

There are also several disadvantages to using corn as a nurse crop for legumes or grasses at this time:

1. Small or special equipment is needed to seed legumes or grasses in the 60 to 80 inches between the corn rows.
2. Conventional two-row 40-inch equipment cannot be used to plant or harvest the corn crop.
3. The thick cornstalk population in the wide rows makes picking difficult.

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4. There will be narrow bands of bare soil in the legume or grass stands where the corn rows were the year before.

5. More work is required to seed the legume or grass in the established corn.

6. Corn yields will be reduced to some extent, but probably not so much as the yield of the small grain nurse crop is now reduced to keep it from smothering the sod crop.

Most of these disadvantages are associated with adapting present equipment to 60 or 80 rows for corn. If the practice of using corn as a nurse crop proves practical, farm equipment companies will soon develop the equipment necessary to do the work.

Success in using corn as a nurse crop will depend largely on proper management and adequate fertilization, especially with nitrogen. The quality of the legume or grass stands will vary with seasons, but it will also be affected by time of planting and seedbed preparation. Weeds in the corn rows will still have to be controlled.

There does not seem to be any good reason why corn spaced in 60- to 80-inch rows should not make a satisfactory nurse crop for legumes or grasses. Whether a farmer elects to use it in this way will depend largely on the type and size of his farm equipment and on his economic situation. If the increased value of the corn nurse crop will offset the increased labor and reduced sod stands, then the practice should prove profitable. In many instances, however, using wide rows and sod seedings in corn can be justified solely on the basis of its value in controlling soil erosion.

S. W. Melsted
3-15-54

AGRONOMY FACTS

NITROGEN IS THE KEY TO GOOD ORGANIC MATTER USE

Soil organic matter is replenished by the use of green manures and crop residues. This recharging of organic matter is important for several reasons. In the first place, the tilth of the soil is related directly to the amount and kind of organic substances that are supplied. Second, plant nutrients are returned to the soil and, if the crop is a nodulated legume, nitrogen may also be added. Third, the availability of nutrients already present in the soil may be increased or decreased, depending on the nature of the organic matter that is added.

All of these results are affected by microbial activity in the soil, and microbial activity is in turn affected by both amount and kind of organic material. Within certain limits, the greater the amount of organic matter, the greater the microbial activity. Even more important, however, is the nitrogen content of the organic materials that are added.

The following data show how the nitrogen content of organic matter supplied by various green manures affects one kind of microbial activity, nitrate formation. In general, the higher the percentage of nitrogen in the added organic matter, the greater the nitrate accumulation.

This experiment was conducted in the laboratory under conditions favorable for nitrate formation. These exact figures will not apply to field soils, but the principles are the same.

The significant point here is the amount of nitrogen supplied in the organic matter, and not the sources from which it comes, because they were selected for their nitrogen content. In providing nitrogen, the stage of growth of the plant may be more important than the kind of plant that is used. In general, mature residues, both leguminous and nonleguminous, are lower in nitrogen than are young succulent materials. Thus it is possible for very young bluegrass to have a higher nitrogen content than mature leguminous crops.

Two processes occur continuously when soil moisture and temperature are favorable for the activity of microorganisms:

1. Nitrogen is released from both applied and native organic matter.

2. Nitrogen is assimilated by microorganisms and becomes a part of their protein and protein-like cell components.

Effect of Nitrogen Content of Green Manures on Nitrate Nitrogen Accumulation

Green manures	Nitrogen	Nitrate nitrogen After 2 weeks	Nitrate nitrogen After 6 weeks
	pct.	lb./A	lb./A
None	...	27	27
Timothy	1.1	6	19
Bluegrass	1.8	28	49
Oat hay	2.2	50	75
Red clover	2.8	45	98
Sweet clover	5.3	71	275

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The result of these interactions may be determined by the accumulation of nitrates in the soil.

When organic matter with a nitrogen content much below 2 percent is added to the soil, the organisms use all of the nitrogen and none of it is released to form nitrates. In fact, nitrate in the soil itself is also built into microbial tissue. The data show that the nitrate content of soil receiving organic material containing 1.1 percent of nitrogen (timothy) was less than that of soil to which no organic matter was applied.

As the nitrogen content of the added organic matter increases, the accumulation of nitrates increases.

It is obvious, then, that plowing under organic matter with a low nitrogen content will decrease the amount of nitrogen available immediately to the crop. This effect may be desirable or undesirable, depending on the objectives to be attained.

If a nonleguminous crop is to be seeded soon after plowing, a nitrogen deficiency may decrease yields if no nitrogen fertilizer is applied. If, on the other hand, no crop is to be grown or if a leguminous crop is to be used, the decrease in nitrates may be desirable.

The benefits derived from applied organic matter depend largely on its decomposition, and not merely on its presence in the soil. The most favorable over-all effects will be secured when leguminous green manures, young succulent nonleguminous crops, or supplementary nitrogenous fertilizers together with residues that are low in nitrogen, are added to the soil.

O. H. Sears
3-29-54

SOIL REACTION PREFERENCES OF CROPS

Crops vary considerably in their ability to produce satisfactorily at different soil reactions. The yardstick used to measure the reaction preferences of plants is the soil pH. Active soil acidity, or its concentration as indicated by pH, is therefore important in determining the ability of a soil to produce any crop.

The hydrogen ion itself is not toxic to plants within the normal pH range of soils. Alfalfa, a very acid-sensitive crop, for example, will grow well at pH 4 in solution greenhouse cultures provided all the essential nutrients are ample. Yet this crop will not grow on soils at pH 4. Differences in soil reaction preferences must therefore be due to variable plant tolerance to secondary factors induced at different pH levels.

The following are the principal secondary factors that might affect plant growth at different soil reaction levels.

<u>Low-calcium and phosphate availability on acid soils</u>. Crops vary in their calcium and phosphorus requirements and in their ability to extract these elements from the available soil forms. The pH of soils is related to the degree of base saturation (SF-19). Calcium is usually the dominant replaceable basic cation in soils. It follows, therefore, that on acid soils with low degrees of saturation the quantity of available calcium also decreases, and it becomes increasingly difficult for plants with <u>high calcium requirements</u> to secure adequate available calcium. Such plants may therefore not be well adapted for growth on acid soils.

The dominant native forms of available phosphorus occurring in soils tend to be related to soil reaction. Above pH 6 on noncarbonate soils, available phosphorus occurs chiefly as an acid-soluble form. Below pH 6 adsorbed phosphorus becomes relatively abundant, and on some strongly acid soils it may even be the dominant available form. Plants are poor feeders on adsorbed available phosphorus on acid soils; and if adsorbed phosphorus is the dominant available form, they make little growth. It is doubtful, however, if phosphate availability basically influences plant preferences. The data cited in Table 1 are for phosphated land. It is evident that reaction preferences vary even with phosphate fertilization.

<u>Toxic aluminum and manganese concentrations on very acid soils</u>. Aluminum and manganese become more soluble as soils become more acid. The tolerance of plants to soluble aluminum and manganese varies. Oats tolerate high soil acidity for several reasons. First, they have a low calcium requirement and can get enough calcium even from strongly acid soils. Moreover, they have a high tolerance to soluble aluminum and manganese. This explains why satisfactory oat yields may be secured even on soils with a pH of 5 (Table 1).

Alfalfa, on the other hand, is very sensitive to soil acidity. Maximum production occurs at or near neutrality. Results published by the Ohio Agricultural Experiment Station (Table 1) indicate a 58 percent yield decrease for alfalfa when the soil pH drops from 6.8 to 5.7.

Alfalfa has a high calcium requirement. The low calcium content of alfalfa grown on soils of even moderate acidity has given rise to the belief that alfalfa is acid sensitive because of inability to secure sufficient calcium. But evidence from Cornell indicates that the high solubility of aluminum and manganese in very acid soils interferes with normal calcium uptake by alfalfa. The inability of alfalfa to secure ample calcium would

therefore appear to be related to its sensitivity to the soluble aluminum and manganese concentrations. Lime reduces the aluminum and manganese concentrations in soil solution and thus removes the block to normal calcium absorption.

Minor element deficiencies induced at alkaline reactions. With the exception of molybdenum, availability of the minor elements, zinc, copper, iron, manganese, and boron, decreases as soils approach neutral to alkaline reactions. Borderline deficiencies of these elements at acid soil reactions frequently become striking if too much lime is applied. This is particularly true on the sandy soils of the South. But Illinois soils appear to be amply supplied with all the minor elements except boron. The possibility of creating minor element deficiencies through the use of lime therefore appears rather remote.

Tolerance of crops to strongly alkaline soil (pH 7.5-8.0) varies. Soybeans growing on shelly spots are often severely stunted and turn yellow. In some instances this condition may be corrected by applying potash. In other cases iron or manganese deficiencies induced by alkaline conditions may be the cause of poor growth. Applying available iron or manganese to the soil would not correct the deficiency because they would immediately precipitate out as unavailable forms. Foliar sprays containing soluble iron and manganese would correct the trouble if the symptoms were caused by a deficiency of these nutrients.

Effects of pH on susceptibility to soil-borne diseases. Susceptibility of crops to certain fungus diseases may vary with soil reactions. Club root of cabbage and potato scab are the classic examples usually cited to illustrate the role of soil reaction in disease control. The organism causing club root of cabbage is more tolerant of soil acidity than the host plant. Liming to about neutrality makes the soil less favorable for growth of the fungus and thereby reduces damage from club root.

Potatoes are very acid tolerant (Table 2). The fungus causing potato scab is less tolerant of soil acidity than its host. Potatoes are often grown on strongly acid soils (pH 5.5 or lower) primarily to avoid the serious damage caused by scab.

From the discussion of factors affecting plant growth at various soil reaction levels, it is obvious that the question of why plants vary in their soil reaction preferences is not simple.

The pH ranges for satisfactory growth of a number of crops are given in Table 2. All plants have a considerable pH range throughout which satisfactory growth occurs. But it does not necessarily follow that maximum yields can be secured throughout the indicated range. The extent to which production may be sacrificed in various crops at various pH levels is given in Table 1. Contrast the yield of oats with alfalfa at pH levels 5.0, 5.7, and 6.8.

Satisfactory growth is occasionally reported at pH levels somewhat lower than those indicated in Table 2. Several factors might be involved in this contradictory evidence. Satisfactory growth is sometimes a matter of opinion. In Illinois the agricultural lime is usually coarse. The rapidity with which soil pH shifts occur after liming depends on fineness of the limestone and degree of mixing. If an adequate amount of coarse lime is applied and thoroughly incorporated, crop roots may contact numerous limestone particles and get ample available calcium. In this case the improved soil calcium status might not be reflected in marked neutralization or pH change for some time. This could lead to different impressions of a plant's relative reaction preference. In general, however, the data in Tables 1 and 2 are the soundest criteria for judging whether growth will be satisfactory.

There are many soils, particularly in northern Illinois, where an acid surface is underlain at 3 to 5 feet by neutral or alkaline substrata. A seeding of alfalfa at a borderline surface soil pH level may make excellent growth once the roots reach the deep-seated calcium supply. In general, this applies chiefly to alfalfa stands held over for 2 or more years. Shallower rooted annual crops and alfalfa stands held for a single year are probably less capable of tapping deep calcium reserves. For such crops the reaction preferences will tend to conform to those given in Tables 1 and 2.

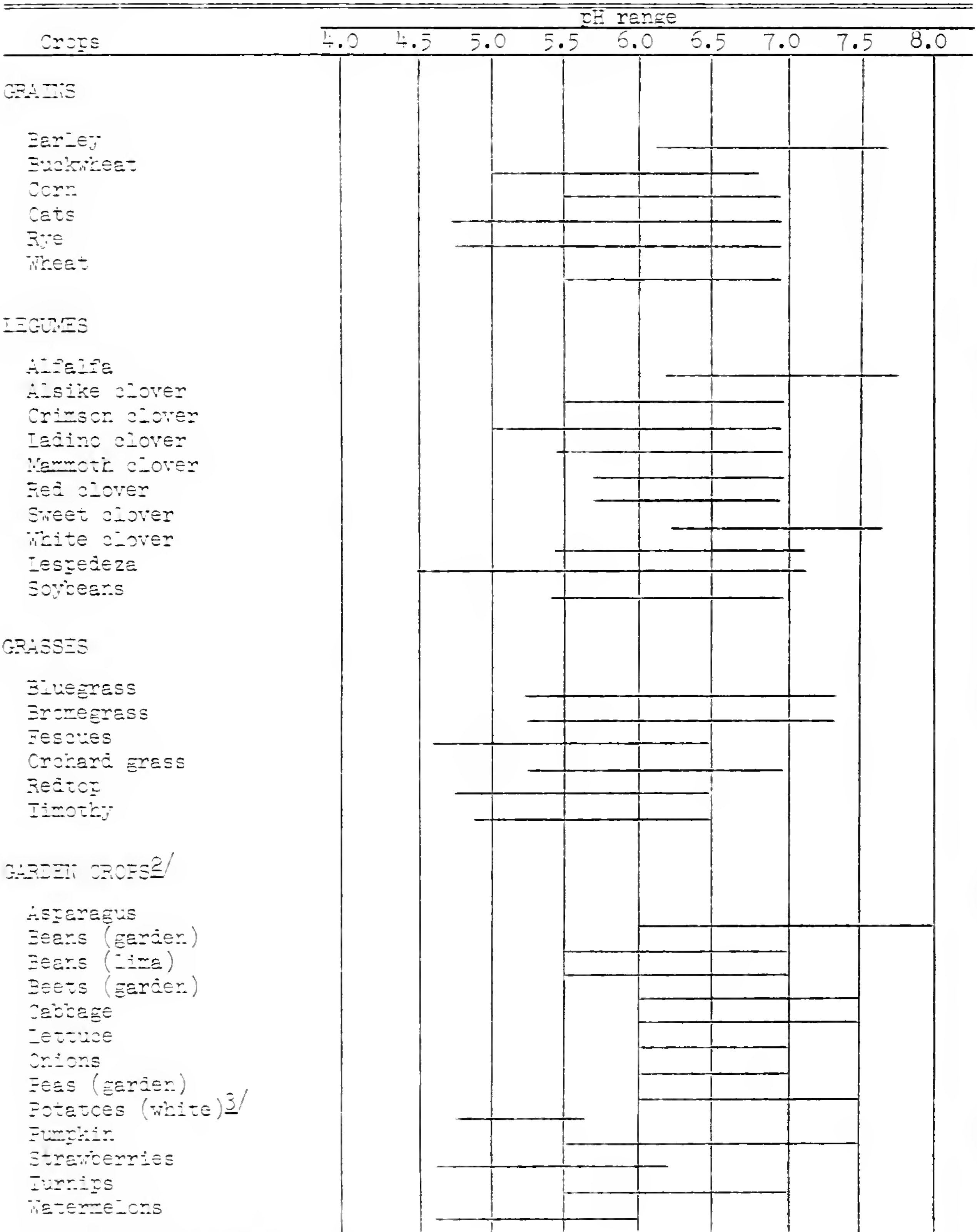
<u>Summary</u>. Plants vary in their soil reaction requirements. Fortunately there is certain flexibility in these preferences. The limiting of growth at a particular range cannot be attributed to any single unfavorable factor. On acid soils growth may be limited by lack of available calcium, phosphorus, or the toxicity of soluble aluminum or manganese. Poor growth in the alkaline range may be due to the low availability of major or minor nutrients. In other cases growth may be improved by the control of disease at specific reaction levels that are unfavorable to the pathogen but not to the host plants.

Table 1.--Relative Yields of Crops at Different Soil Reactions[1/]

pH of soil	Percent of maximum yield										
	Corn	Wheat	Oats	Barley	Alfalfa	Sweet clover	Red clover	Alsike clover	Mammoth clover	Soybeans	Timothy
4.7	34	68	77	0	2	0	12	13	16	65	31
5.0	73	76	93	23	9	2	21	27	29	79	47
5.7	83	89	99	80	42	49	53	72	69	80	66
6.8	100	100	98	95	100	89	98	100	100	100	100
7.5	85	99	100	100	100	100	100	95	99	93	95

1/ Ohio Spec. Cir. 53, 1938. Phosphated land.

Table 2.--The pH Ranges at Which Satisfactory Growth Occurs[1]



1/ Information from various sources.
2/ For other garden crops see H-420.
3/ pH 5.6 - upper limit for scab disease control.

E. H. Tyner
April 5, 1954

CORN AS A SOIL BUILDER

Corn is often regarded as being hard on the soil. For this reason it has not been recommended as a crop to grow continually on any given area. In fact, continuous corn production has generally been considered the worst treatment a soil could have.

But today we know that it is not the corn crop itself that is responsible for the soil deterioration, but the improper tillage and management practices that are used in producing corn. With the use of improved cultural practices, corn could actually become a soil-building crop.

Row crops like corn and soybeans lend themselves to excessive cultivation. Generally overtillage and underfertilization, especially with nitrogen, are responsible for the damage observed on the land. This damage is usually reflected in the following soil characteristics:

(1) Rapid loss of soil organic matter and accompanying loss of soil tilth resulting from use of too little nitrogen.

(2) Excessive soil erosion resulting from lack of soil cover under clean cultivation practices, and too fine a breakdown of soil structure resulting from excessive tillage.

(3) Increased loss of water due to excessive evaporation from the bare soil surface, and poor penetration of rain water where desirable soil structure has been destroyed by overtillage.

To make corn a soil builder, tillage and management practices must be modified to overcome the damage that present practices are causing.

The first requisite in making corn a soil builder is to use adequate nitrogen fertilizer, along with a fertilization program that puts all nutrients into positive balance. When corn is adequately fertilized, more plant food nutrients are returned to the soil than the corn crop removes, and loss of soil organic matter is reduced to a minimum. Maintaining soil organic matter depends on returning adequate amounts of crop residues and nitrogen to the soil.

Plowing down a little nitrogen (20 to 30 pounds an acre) with the cornstalks will help to decompose them and keep a supply of active organic matter in the soil. Cornstalks, or any other crop residues that are low in nitrogen, do not make good soil builders unless they are supplemented with nitrogen. Supplementing low-nitrogen residues with nitrogen will, in turn, help to maintain good soil tilth.

A second requisite in making corn a soil-building crop is to decrease tillage operations as they are now practiced and provide a cover for the soil during the winter and early spring. Excessive tillage helps to destroy soil organic matter, and consequently soil tilth. Cutting down the amount of cultivation will make the soil more resistant to erosion.

Sod crops tend to improve soil tilth, but the excessive tillage that usually follows a sod crop in preparing for the corn crop often destroys much of the advantage resulting from the sod crop. Sod seedbeds and mulch planters are being investigated and recommended on a trial basis because they reduce tillage operations. When these practices are used, the corn is planted directly in the sod in a sort of once-over operation. Then the crop is cultivated only enough to control weeds.

The third requisite in making corn a soil builder is to control the erosion losses now associated with clean cultivation of row crops. For corn, the erosion losses

can be minimized by seeding fall cover crops. When corn is seeded in a sod seedbed, the soil has cover during the entire year. If the sod seedbed contains a living crop, a living mulch system is established. This system is very effective in controlling erosion, but its success depends on adequate nitrogen fertilization and water.

If the sod crop is destroyed by chemical sprays or by cutting, a dead (trash) mulch system is established. Both the living and trash mulches are effective in controlling erosion. They do, however, require special equipment for seeding the corn. Under either system only a minimum amount of cultivation is required to control weeds.

Fall-seeding a grass or small grain in the corn to provide winter cover for the soil is recommended where corn is grown on sloping land that is subject to erosion. When properly fertilized, rye will usually produce enough growth in the fall to cut down erosion. Shredding the cornstalks in the fall and leaving them on the land will provide a mulch cover for the soil and lessen damage from beating rains.

On well fertilized soil that is properly managed, corn grown continuously can well become a soil-building crop. When yields are high, a large amount of crop residues is returned to the soil. With high nitrogen fertility, cornstalks that are returned to the land will contain fairly large amounts of nitrogen that will cause them to decompose more rapidly and form active soil organic matter.

Because continuous corn will produce more crop residues than almost any crop rotation, corn can become one of the best crops a farmer can grow to build up his soil.

Under improper cultural and management practices, any crop can destroy the soil. It is the tillage and fertilizer practices that determine the amount of damage a crop will do to a soil. Like any other crop, corn can be a soil builder if it is properly managed. Whether it is grown continuously or in rotation, the cultural practices should be such that they are soil conserving. This means high fertility, minimum cultivation, and introduction of cover crops on land that is subject to erosion.

S. W. Melsted
5-10-54

ORGANIC MATTER REPLENISHMENT

Soil organic matter is not being maintained on most farms in Illinois where an intensive system of cropping is being practiced. Whether it is essential to maintain organic matter on all soils has not been established, but there is a level below which maximum productivity cannot be expected.

It is necessary to replenish organic matter if unfavorable physical, chemical, and biological conditions are to be avoided. This replenishment, or recharge, is made through the use of farm manure, green manure crops, and crop residues, and the needed amount relates directly to the management and productive capacity of the soil. Land on which large crops are grown furnishes larger quantities of organic material than soils that are low in productivity and therefore requires more replenishment.

A favorable soil reaction and a supply of available phosphorus and potassium are prerequisites in organic matter replenishment. Because nitrogen is needed in largest quantities, and is more generally lacking than other plant foods in soils, it is an important key to organic matter recharge.

The organic materials that are added to soils undergo rapid changes as a result of microbial activity. Much is released as carbon dioxide and water, and part is synthesized by soil microorganisms. There remains the part of the organic materials that is resistant to decay. This residual resistant part, together with the microbial tissues, is sometimes called humus.

As indicated previously (SF 23), the rate of decomposition of the added organic material is affected by its nitrogen content and by the supply of available nitrogen in the soil. When the nitrogen content of the residues is below approximately 1.75 percent, rapid decomposition does not occur unless the soil contains a considerable amount of nitrogen in an available form.

The average nitrogen content of cornstalks is about .85 percent, or 17 pounds per ton. If the nitrogen content were 1.75 percent, the stalks would contain 35 pounds per ton. Thus the addition of 18 pounds of nitrogen per ton of stalks ought to be sufficient to insure decomposition. However, this amount would need to be uniformly distributed throughout the added organic material, a condition that would not exist if the needed nitrogen were added to the soil in the form of ammonium sulfate, ammonium nitrate, or some other nitrogen carrier. Thirty-five pounds of nitrogen should insure rapid decay of the cornstalks without a drain on the supply of available nitrogen furnished by the native soil organic matter, or humus.

Of the constituents of organic materials that are added to soils, the proteins and carbohydrates are readily decomposed, whereas the lignins and waxes are more resistant. Lignin, particularly, is an important contributor to the humus fraction of the soil, because it decomposes so slowly and is present in appreciable amounts in many plants.

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Crops differ considerably in the amount of lignin they contain. In a given plant the proportion of lignin increases with stage of maturity. For instance, young rye plants contain 10 percent of lignin and 2.5 percent of nitrogen, whereas mature plants contain 20 percent of lignin and .5 percent of nitrogen.

Unlike rye and wheat straw, many legume crops are low in lignin. Soybean plants and alfalfa contain about half as much lignin as cereal straws. Because of this lower lignin content and their higher nitrogen content, legumes may not, in themselves, be quite so conducive to the formation of humus as are some of the nonlegume crops. On the other hand, the legumes may contribute indirectly to humus accumulation by increasing the amounts of residues that may be added to soils as humus-forming materials.

O. H. Sears
5-24-54

AGRONOMY FACTS

EVALUATION OF CATCH CROPS

The term catch crop is used here to indicate a legume or a mixture of legumes grown in a grain field for the purpose of improving the soil for the following crops. Seeded in winter grain in February or March or in spring grain at seeding time, catch crops become established before harvest and usually cause little or no interference with the grain crop.

With favorable season and soil conditions, catch crops make large fall growth that can be plowed under very late in the fall or in April or early May in time to prepare the seedbed for corn.

Sweet clover has been very effective because of its rapid, vigorous growth. Total root and top weight of sweet clover catch crops sampled in mid-April of the year after seeding has ranged from 1 1/4 to 2 tons of dry matter per acre containing 80-195 pounds of nitrogen (Bulletin 539). The part of this nitrogen that comes from the air differs somewhat depending on soil conditions, but it is generally believed to be about two-thirds of the total in the crop.

Many comparisons of catch crops have shown alfalfa to be almost as efficient as sweet clover, and even superior to it in some cases. Red clover and mammoth clover are also very effective. These legumes are being used alone or in mixtures with sweet clover on many farms in areas where the sweet clover weevil is a serious threat.

The value of catch crops may be estimated by several yardsticks, such as control of soil erosion, depth of root penetration, total top growth, and effect on soil tilth. However, the most realistic test is the long-time effect on crop yields.

Many field tests have shown legume catch crops to be most effective when used in combination with nonlegume residues. This is demonstrated on the experiment fields at Aledo, Hartsburg, McNabb, and Minonk, where a corn, corn, oats, and wheat rotation has been in use for several years. These fields also have a rotation of corn, corn, oats, and legume hay and therefore the effect of catch crop vs. standover hay can be compared.

Results at Urbana on Flanagan Silt Loam
Rotation: Corn, Corn, Oats (Catch Crop), Wheat (Catch Crop) Since 1937
Annual Acre Yields and Values, Last Four Years

	Corn 1st year	Corn 2nd year	Oats	Wheat	Acre values all crops
	bu.	bu.	bu.	bu.	
No catch crop	62	60	43	28	$69.83
Catch crop	90	73	54	34	88.14
Increase	28	13	11	6	$18.31

Results at Urbana on Drummer Clay Loam
Rotation: Corn, Oats (Catch Crop) Since 1936
Annual Acre Yields and Values, Last Four Years

	Corn	Oats	Acre value
	bu.	bu.	
No catch crop	71	40	$64.76
Catch crop	94	42	81.18
Increase	23	2	$16.42

Results at Dixon on Muscatine Silt Loam
Rotation: Corn, Oats (Catch Crop), Wheat (Catch Crop) Since 1927
Annual Acre Yields and Values[a], 1950-1953

	Corn	Oats	Wheat	Acre value
	bu.	bu.	bu.	
No catch crop	55	32	21	$41.32
Catch crop	95	50	27	75.13
Increase	40	18	6	$33.81

Results at Ewing on Cisne Silt Loam
Rotation: Corn, Wheat, Winter Oats (Catch Crop)
Annual Acre Yields and Values[a], 1950-1953

	Corn	Wheat	Winter oats	Acre value
	bu.	bu.	bu.	
No catch crop	38	4	18	$26.80
Catch crop	58	13	23	44.62
Increase	20	9	5	$17.82

a/ From soil experiment field mimeographs.

Aledo, Hartsburg, McNabb, Minonk
Average Crop Yields and Values[a], 1950-1953

	Corn 1st year	Corn 2nd year	Oats	Wheat	Legume hay	Acre value
	Rotation: Corn, corn, oats, wheat					
	bu.	bu.	bu.	bu.	tons	
No residues and no catch crop	51	50	38	21		$57.78
Residues and catch crop	81	68	44	26		79.58
Increase for residues and catch crop	30	18	6	5		$21.80
	Rotation: Corn, corn, oats, hay					
No treatment	84	77	51		2.1	$85.18
Advantage for standover compared with catch crop	3	9	7			5.60

a/ From soil experiment field mimeographs.

SOIL EXPERIMENT FIELD STAFF
5-31-54

AGRONOMY FACTS

W-1

GIANT FOXTAIL (*Setaria faberii*)

We have four common types of foxtail in Illinois--giant, green, yellow, and sticky. If giant foxtail, the most serious of the four, continues to spread, it will be our worst weed. At present it is concentrated chiefly in east-central Illinois, but some can be found in every county in the southern three-fourths of the state.

Giant foxtail can be distinguished from other foxtails by its long, lopping head and its unusual size. If left undisturbed, it will grow seven feet tall. Another distinguishing feature is the short hairs covering the upper sides of the leaves.

The weed usually starts to germinate about April 20 in central Illinois. If left undisturbed in fencerows it will produce seed by July 15. Seed production usually continues until frost through new spikes appearing from the lower nodes. Type of ground cover does not seem to matter, as the seed can be found in legumes, fencerows, or plowed fields at about the same time in the spring. Established legumes or winter grains may greatly hinder its development, but it grows rapidly as soon as the crop is removed.

Although giant foxtail seed has not been tested for longevity, its viability is probably good, as green and yellow foxtail seeds have germinated after being buried for 20 years.

No good cropping system has been found that will control this weed. It survives competition from cultivated crops as well as from rotations that include small grains and stand-over legumes. The only crop that offers possibilities for control is winter wheat. Since the wheat is well established in early spring, it competes well with giant foxtail and is harvested before the weed produces seed. Plowing immediately after wheat harvest will prevent seed production, and later cultivations will reduce the seed supply.

Spring oats have not proved to be a good competitor. Often giant foxtail produces seed about the same time as the oats. In a few instances when oats seeding has been delayed, the weed has grown faster than the oats and made harvest impossible.

Infestations in corn and soybeans may or may not be serious, depending on cultural practices. If cultivations are timely and are not interrupted by rain, the crops may be completely free of foxtail. On the other hand, rain combined with untimely cultivations usually means heavy infestations. Delays of a week or 10 days in the first cultivation may cause farmers to disk up corn and bean fields and replant. Because the foxtail becomes so well established that normal row cultivation will not remove it.

Giant foxtail will continue to germinate during the summer if there is moisture,but summer germination is small compared with that at crop-planting time. Legume crops are one of the worst offenders in spreading this weed. If the legume is cut for hay or left for seed, giant foxtail produces abundant seed; but if the legume is grazed, very little foxtail seed develops. Getting good legume stands in infested areas is becoming a serious problem.

After the nurse crop is removed, the weed grows rapidly, offering severe competition to the seeding. Three clippings during late summer will prevent 90 percent, but not all, normal seed production. Few farmers are willing to clip meadows three times. Grazing the

forage is therefore a better way to prevent seed production.

Use of chemicals for control offers limited possibilities. Pre-emergence sprays are sometimes effective in corn, but their success varies with the weather. However, results have been good enough to recommend spraying around the edges of fields where giant foxtail seems to concentrate in the early stages. TCA has proved 100 percent effective, but it will also injure corn, small grains, and soybeans. It can be used in fencerows and in established alfalfa fields.

Although no control measures are entirely effective, the following practices will help to reduce giant foxtail infestations:

1. Check corn instead of drilling or hill-dropping. Cross cultivation will be helpful between hills.

2. Use clean crop seed. Unless crop seed has been thoroughly cleaned, it may be heavily infested with foxtail seed.

3. Clean up harvesting equipment. Combines and balers carry the weed to many clean fields. Clean equipment before moving to the next field.

4. Use 2,4-D as a pre-emergence spray around borders in cornfields. Apply two pounds of 2,4-D ester per acre after corn planting. If there is enough moisture, this treatment will work. Do not cultivate border rows as long as no foxtail appears.

5. You may use TCA in fencerows and established alfalfa. Applying TCA at 10 pounds per acre when foxtail is germinating will eradicate it. This rate will not harm established alfalfa but will injure red clover. Use the same rate in fencerows when the foxtail plants are emerging. There may be some later reinfestations from late germination.

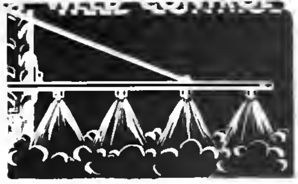
6. Graze infested areas. Livestock will eat giant foxtail readily in the vegetative stages. Most seed production can be prevented by grazing.

7. Remove scattered plants by hand; it is the best way to control new infestations.

8. If grazing is not possible, clip to help prevent seed production. Clipping is not entirely effective, but it reduces the amount of seed and thus helps in control.

9. Grow winter wheat for three years, and plow immediately after harvest. Summer cultivation should greatly reduce the seed population. Growing winter wheat every few years in a rotation should reduce infestations, but it is not so effective as continuous wheat for several years.

F. W. Slife
1/12/53



CONTROLLING WEEDS IN SOYBEANS

The best way to control weeds in soybeans is to use good cultural practices. The most effective practice is to prepare the seedbed early and then wait several weeks so that a few crops of weeds can be destroyed before the beans are planted. Delayed planting usually means that the soil will be warmer and the beans will germinate and develop more quickly.

In Illinois soybeans are usually planted in rows as a weed control measure. Row planting permits cultivation between the rows and helps to control late germinating weeds by covering them with dirt from the cultivator.

Our weed problem in soybeans has increased steadily from year to year. The combine harvester has probably added to the problem by distributing the weed seeds over the fields and moving them from farm to farm.

The number of weeds in soybeans will depend largely on the weather. If the cultivations are timely and not interrupted by rain, soybeans are likely to be the cleanest crop on the farm. But if the cultivations are interrupted by rains, soybeans are often the weediest crop we have.

Chemical control of weeds in soybeans has developed slowly because the beans are sensitive to most of the chemicals that have been tested. At present the Illinois Agricultural Experiment Station is recommending chemical weed control on only a limited basis. <u>Chemicals should be used on soybeans only when in past years cultural practices have failed to control weeds and yields have been severely reduced</u>.

There are several chemicals that do offer limited possibilities for controlling weeds in soybeans. These chemicals are pre-emergence herbicides, which are applied to the soil before the weeds and beans emerge.

The effectiveness of pre-emergence treatments depends largely on the weather. If a pre-emergence chemical is applied to a dry soil and the soil remains dry for two or three weeks, much of the chemical will be lost or will decompose. Rains after that time will cause many weeds to grow. If, however, the treatment is applied to a soil that has enough moisture to insure prompt germination of weed seeds, the chemical should be effective in killing the weeds.

The most effective chemical for pre-emergence treatment of soybeans has been dinitro-ortho-sec-butyl-phenol (called dinitro). The recommended rate of application is between 6 and 8 pounds of acid dinitro-phenol per acre as an overall treatment. The 6-pound rate is recommended for the lighter soils and the 8-pound rate for heavy soils or for soils with a high clay content. <u>Under no circumstances is this material recommended for sandy soils</u>.

Because the cost for complete coverage is so high, it seems best to treat a band about 12 inches wide over the row. For band treatment the per acre cost is \$3.00 to \$4.00. As a rule the treatment should be applied immediately after planting. Delaying the application until two or three days after planting will usually increase control. But if it should rain, the application may be prevented altogether because of wet weather.

The most efficient method of application is to apply at planting time with a sprayer mounted on the planter so that the material is applied behind the planter wheels. Not all types of weeds can be controlled by this chemical. It will usually control annual broad-leafed weeds but not the annual grasses. Giant foxtail or wild millet cannot be successfully controlled at the 6- to 8-pound rate of application. Ten pounds will control giant foxtail, but soybeans will not tolerate this rate. Perennial weeds or weeds coming up from underground roots are not materially affected by pre-emergence treatments.

If dinitro has been applied as a pre-emergence treatment and no weeds are emerging, it is important not to cover the treated area with dirt from the cultivator. Dirt over the treated area will introduce new weed seeds. This can be prevented by using fenders or by using a blade cultivator that cuts the weeds off and does not throw much dirt.

Occasionally dinitro will slightly reduce soybean stands, but in the tests it has never caused a reduction in yield.

Another chemical that holds some promise as a pre-emergence herbicide for soybeans is Chloro IPC. However, because it has not been tested thoroughly enough, we cannot recommend it until another year's tests have been completed.

Chloro IPC at 6 to 8 pounds used as a pre-emergence spray on soybeans has been slightly better than dinitro in controlling grass weeds. It has been less effective, however, against cocklebur and giant ragweed. Smartweeds seem to be particularly sensitive to Chloro IPC, and it may be that this chemical can be used in soybean fields that are infested mainly with smartweeds. Because of cost it will have to be applied as a band treatment, and it probably should be applied immediately after planting.

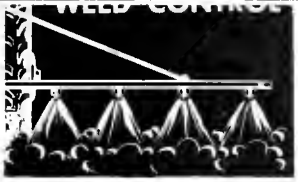
As yet no chemical has been found that is effective in controlling weeds in soybeans after the beans have emerged.

We are not recommending pre-emergence control of weeds in complete soybean fields until some experience with these chemicals has been obtained. By far the best plan now is to treat several rows across soybean fields or around the ends and compare the results with those in unsprayed areas. When some experience has been obtained, the decision on whether to use pre-emergence weed control in soybeans will be up to the individual farmer.

F. W. Slife
4/13/53

UNIVERSITY OF ILLINOIS · COLLEGE OF AGRICULTURE

AGRONOMY FACTS



W-3

BRUSH CONTROL

Brush control is a problem that affects almost every type of property. Undesirable brush can be found growing on most farms, along railways, highways, and drainage ditches, and around industrial plants. It is true that certain types of brush provide food and cover for wildlife or may have other values. But these types are not the ones that present a problem.

In the past brush had to be removed by mechanical means. Often the cost was prohibitive and the brush was allowed to remain; hence the problem has increased. With the introduction of 2,4-D, 2,4,5-T, and other chemicals, however, many types of brush can now be eliminated easily and at relatively low cost.

There are several older chemicals that have been effective in controlling brush. One of them, sodium arsenite, has been used extensively in some areas to kill large trees. It is very effective for this purpose and is reasonable in cost. The usual method is to apply the chemical in a frill around the trunk or pour it into holes bored in the trunk. Because it is extremely poisonous to humans and livestock, however, it is not recommended for use by the average farmer.

Ammate or ammonium sulfamate is another woody plant killer that has been on the market for a number of years. If is effective on certain types of brush, but not so effective on others. Because it is expensive, it has not been used so widely as 2,4-D and 2,4,5-T. It will also corrode equipment unless it is thoroughly cleaned after use.

Although ammate is irritating to humans, it is not poisonous. It can be used as a foliage spray, as a frill treatment, or as a stump treatment to prevent resprouting.

2,4-D and 2,4,5-T are the latest chemicals to be used in controlling brush. They are noncorrosive, nonpoisonous to humans and animals, and reasonably cheap. If used correctly they are effective in eliminating many of our serious brush problems. One hundred percent control is seldom achieved with one application, however; at least two applications are needed to do a complete job.

These two chemicals can be used in several ways to eliminate brush. Among them are foliage sprays, basal bark treatment, and stump treatment.

Foliage sprays. Types of brush vary in their susceptibility to these chemicals. Most species are more susceptible to 2,4,5-T than to 2,4-D, although at least one is affected more readily by 2,4-D. Some others are equally susceptible to either one.

For spraying mixed types of brush, it is best to use a combination of 2,4-D and 2,4,5-T. The mixture costs less than 2,4,5-T alone and yet gives as good results. The only exception is buckbrush, which is most susceptible to 2,4-D.

Application rates are given on the container, but the best rate seems to be 4 pounds of acid in 100 gallons of water. There is no advantage to using oil instead of water as a carrier. A heavier rate will kill the top growth too fast and will not allow the chemical to penetrate the root system.

Foliage sprays can be applied at any time after the leaves are fully developed in the spring. They do, however, have the following limitations that should be considered before a spraying program is started:

1. Foliage sprays are most effective against small brush or regrowth up to 15 feet tall. It is not practical to try to kill tall trees by this method.

2. Several species are almost resistant to foliage sprays. Oaks, maple, hickory, and ash can not usually be controlled by this method.

3. Drift from foliage sprays can cause serious injury to nearby susceptible crops.

Basal bark treatment consists of painting the lower part of the trunk with 2,4,5-T in oil at the rate of 16 pounds of acid per 100 gallons of oil. Mixing in an oil-soluble dye or a small amount of paint will help to mark treated areas. It is important to completely encircle the trunk and to cover it thoroughly from the ground line up to 15 inches above the ground level. The mixture should be applied to the point of runoff, and the ground line should be thoroughly soaked.

Basal bark treatment has the following advantages over foliage sprays:

1. It can be used on taller trees. Although there seems to be no height limit, on trees more than 8 inches in diameter, it may be more economical to frill.

2. The basal bark treatment can be applied during the winter whenever the weather permits, although it seems to be effective at any time during the year.

3. There is no danger of drift from the basal bark treatment if it is applied during the winter.

4. No special equipment is required. An ordinary 3-gallon knapsack spray seems to be best.

5. The treatment is effective against species that are not easily controlled with 2,4-D.

Stump treatment. When growing brush is cut down, it is advisable to treat the stumps to prevent regrowth. The recommended mixture is 16 pounds of 2,4,5-T acid in 100 gallons of oil. The top and sides of the stump should be treated to the point of runoff. Application should be made soon after cutting.

Only the ester forms of 2,4-D and 2,4,5-T should be used to control brush because they are more effective than the amines. The low-volatile esters seem to have an advantage over the normal esters because they produce less gas.

The best method of controlling brush depends on individual circumstances. If it must be removed at once, it may be better to use a bulldozer or other implement than a chemical. If the top growth must be removed quickly, it would be best to cut the brush green and then treat the stumps to prevent regrowth.

Foliage sprays and basal bark treatment can be used to best advantage in fencerows and drainage ditches and on scattered brush in pastures. A year or so after chemical treatment, the dead brush can be removed by hand or with a tractor.

F. W. Slife
11-16-53